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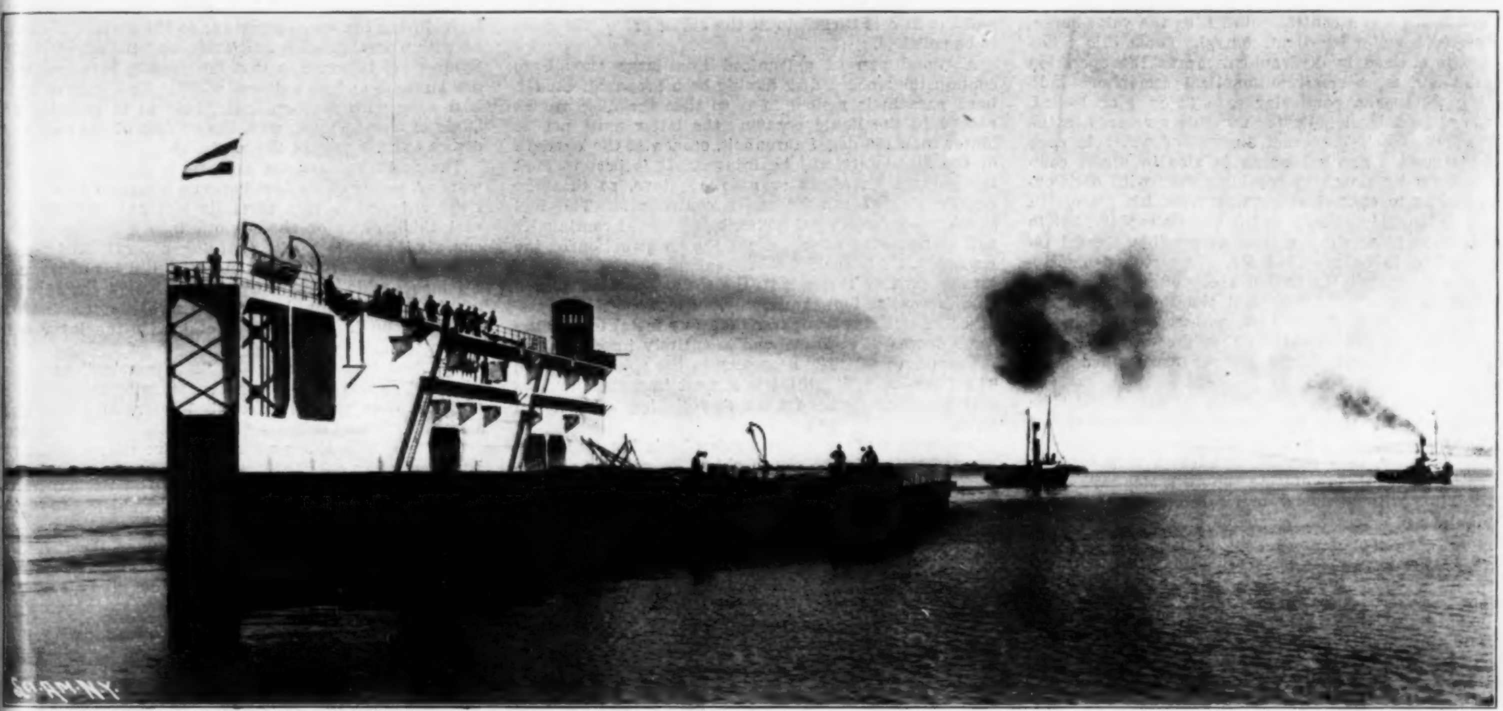
A NEW OFFSHORE FLOATING DOCK.

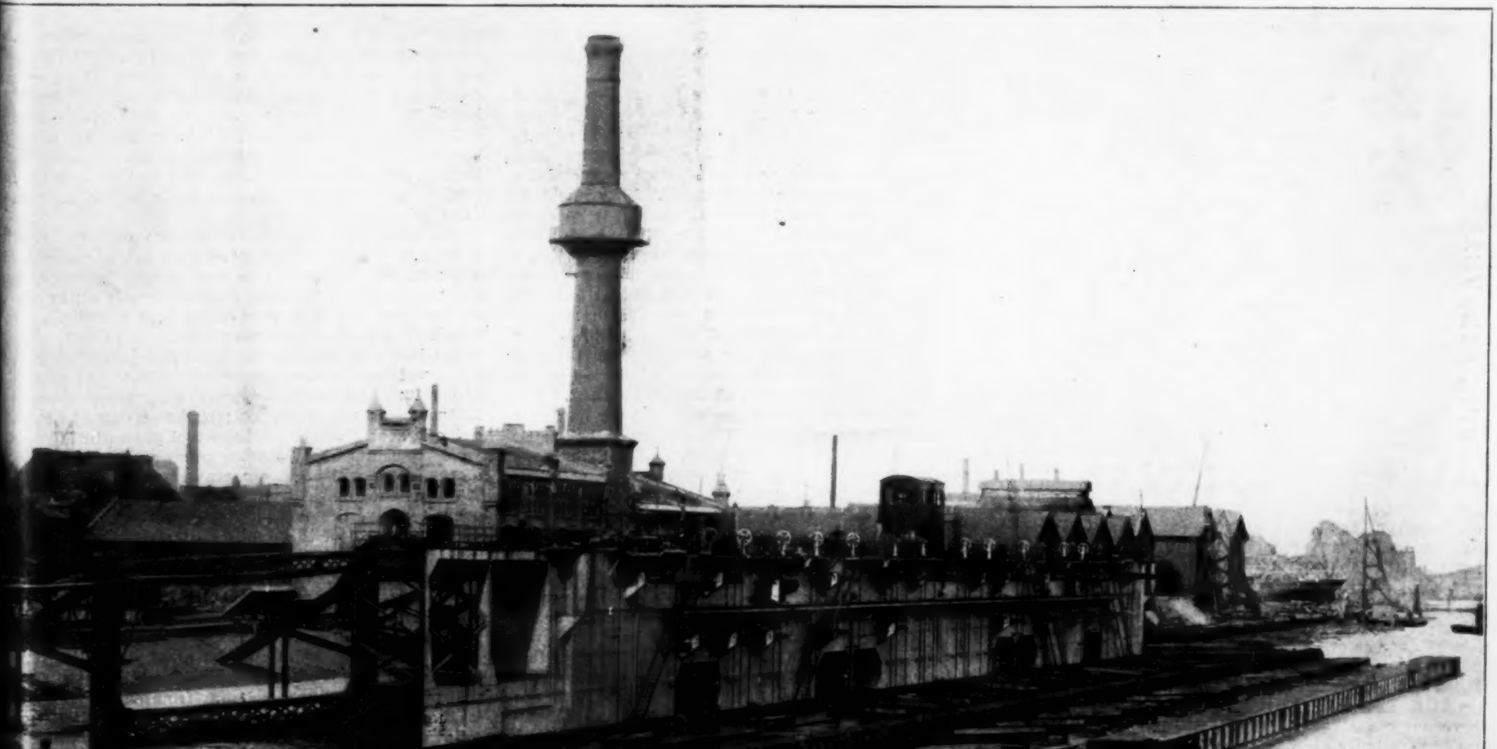
By Our Berlin Correspondent.

A new floating dock has recently been added to the large number of similar docks in the port of Hamburg. At this port the floating dock is almost the only type of ship-repairing structure used. The particular dock illustrated differs from most others in Hamburg in some of its structural features. It was necessary to comply with some peculiar conditions. The river was so narrow at the place where the dock was to be used that no mooring rights could be obtained in the stream, so as to exclude any possibility of using the ordinary double-side type of dock, into which vessels enter by the end. The one-sided type was adopted accordingly.

The dock was designed to have a maximum lifting power of 11,000 tons. As will be seen from the accompanying photographs, the dock was tied to the shore by nine sets of double parallel booms, of which two are A-shaped, so as to be able to lay hold of the dock also in its longitudinal direction, and to prevent any vibrations. To the same effect were provided two additional sets of booms, which are strongly cross-braced into pairs. The columns are built into concrete sockets formed by steel cylinders that are sunk into the river bed; these were filled with concrete after the soil had been removed. They are tied to the shore by means of



TOWING THE DOCK TO ITS DESTINATION.



THE NEW OFFSHORE DOCK OF THE PORT OF HAMBURG.

A GERMAN ONE-SIDE FLOATING DOCK.

steel ties fitted into concrete, all the columns being connected by means of lattice girders. The end and central booms serve as gangways leading to the top deck, while in addition to these, broader gangways lead down to the pontoon deck, passing through passages in the walls.

The over-all length of the dock proper is 508.4 feet. The bow is tapered and has a length of 73 feet. The stern is approximately square on the land side, but the river side is tapered off to the same angle as the bow. The maximum beam of the dock is about 100 feet, the position of the keel blocks being such that the maximum beam of vessel to be taken is 76 feet, so that a working space of 4 feet between the side of the ship and face of the wall is allowed. The normal draft of the dock being 22 feet necessitated the dredging of the river bed up to the depth required.

The machinery plant is located in the dock between the two longitudinal walls; it consists of eight sets of 18-inch centrifugal pumps driven each by a compound horizontal engine, direct-connected with the pump shaft. According to the contract, the engines had to be of sufficient power to lift an 11,000-ton vessel in at most one and one-half hours. On the official trial, they succeeded in lifting a 10,000-ton vessel in one hour, which may be called a very satisfactory result. The steam necessary for the operation of the engines is supplied from a set of boilers placed on shore, the steam being conducted to them through articulated pipes running along the shore-booms. The whole pumping plant is operated from a central point, i. e., the valve-house, so as to be under excellent control. From this valve-house is effected by hydraulical means the operation of the sluices, a small automatical semaphore indicating whether a particular gate is open or locked, while a water-level indicator accurately records in the valve-house itself the exact amount of water in each compartment. The valve-man is also in direct communication by means of speaking-tubes with each engine, so as to control everything from his place. In order to be able not only to lift vessels rapidly, but to berth them in as short a time as possible, special facilities had to be provided for. Powerful steam-capstans were placed for this purpose on the top deck, whereas a series of mechanical side-shores were provided in the wall of the dock, which can be screwed out to any desired extent, so that the centering of a ship over the keel blocks can be ascertained with safety.

In addition to the twenty ordinary mechanical side-shores, ten very large and powerful hydraulic shores were provided, which are so arranged that while advancing slowly, they can be withdrawn very rapidly, so as to enable ships entering the dock sideways to be placed in position rapidly and safely. The bilges of the ship are supported by means of mechanical bilge shores, consisting of water-tight steel cases and worked from the top deck. They are fitted with a timber lining, one end being pivoted to the deck, while the other is raised by means of a steel rack and pinion actuated by a crank mechanism.

Both the engine and other rooms are provided with electric light installation, arc lamps being carried on gallows on the top deck for outside illumination, while numerous flood boxes have been fitted, whence separate lamps may be taken for lighting any desired spot. For the washing of vessels, testing of tanks, and the thawing of the valves of the docks in winter, there have been provided cold and hot water mains.

[Continued from SUPPLEMENT No. 1512, page 24230.]

ON THE MODERN REFLECTING TELESCOPE, AND THE MAKING AND TESTING OF OPTICAL MIRRORS.*

By G. W. RITCHEY.

V. POLISHING TOOLS.

AFTER experience with polishing tools of various kinds, the tools which I now use exclusively for large work consist of a wooden disk or basis constructed in a peculiar manner, and covered on one side with squares of rosin faced with a thin layer of beeswax. The wooden disk may be replaced, in the case of small polishing tools up to 12 or 15 inches diameter, by a ribbed cast-iron plate so designed as to be extremely light and rigid; the bases of larger tools may be made of cast aluminium, but this, in order to be strong and rigid, must contain 15 per cent or more of other metals; such a basis for a 30-inch polishing tool weighs about sixty pounds, and the rough casting alone costs about fifty dollars. It is possible that a metal basis possesses an advantage over a wooden one in that its surface is less yielding. Tools properly constructed of wood, however, are light and extremely rigid, are easily made, and are economical in cost. As their proper construction is a matter of the utmost importance, I shall describe, somewhat in detail, the method of making wooden bases of from 15 to 40 inches diameter.

A large number of strips of dry and straight-grained pine wood 1¼ inches wide and 5-16 inch thick are prepared; the wooden basis is built up of successive layers of these strips. The strips in all layers except the two outer ones are laid just ¼ of an inch apart. Those of each layer are placed at right angles to those of the next layer below, and are glued and nailed down with long wire brads. The best cabinet-maker's glue is used, and the strips are warmed before the glue is applied. Each crossing of the strips in the successive layers (i. e., each of the 1¼-inch squares) is nailed with at least two nails. The upper surface of each layer is carefully planed flat before the next layer of strips is applied. For a 20-inch tool six layers of pine strips (each 5-16 inch thick) are used; for a 24-inch tool, seven layers; for a 36-inch tool, ten layers. Next, one layer of thoroughly seasoned strips of hard straight-grained cherry wood about ⅜ inch thick and slightly less than 1½ inches wide is added, to form the outer layer at the back of the tool; these strips are laid almost touching each other. In the case of tools for flat mirrors, a precisely similar layer of cherry strips is added to form the outer layer at the front or face of the tool. But in the case of tools for concave or convex mirrors the strips composing the front layer must be made thicker, to allow for the curvature of the face of the tool. If this curvature is great, the cherry strips forming the front layer are made of double width (i. e., slightly less than 3 inches wide), in order that the width of their bases shall be greater as compared with their thickness; this is usually done when the depth of the curve is greater than ¼ inch. The gluing and nailing of the outer layers of strips are done with the greatest thoroughness, four of the long fine nails being driven through into each of the squares of pine wood beneath. For tools less than 20 inches in diameter thinner strips and a larger number of layers are used. The entire thickness of the wooden disk or basis built up in this way should be between one-tenth and one-eighth of its diameter.

This wooden basis is next placed in a large lathe, the edge is turned smooth and to the proper diameter, and the face is turned to fit the curvature of the glass to be polished.

A round pan of galvanized iron large enough to contain the wooden disk having been prepared, enough hard paraffin is melted in it so that the disk can be soaked in the liquid paraffin; the latter must not be hotter than 150 deg. Fahrenheit, otherwise the strength of the glue-joints will be injured. It is best to melt the paraffin on a gas or gasoline stove, so that the degree of heat can be easily controlled. The tool should soak for several hours, being moved continually and turned over often. Since the construction of the wooden basis is such that a great number of openings extend entirely through it, the melted paraffin permeates the entire tool thoroughly. The wooden tool prepared in this way is lighter than any metal tool of the same degree of stiffness, and is entirely impervious to the moisture which is necessary in the polishing room. The question of lightness is a most important one, as will be seen when the work of polishing is described later.

The front or face of the wooden basis is now lightly scraped with a wide, sharp chisel, to remove any excess of paraffin, and is then marked off for 1¼-inch squares of rosin, with grooves ¼ inch wide between them; the grooves should come exactly above the ¼-inch spaces left between the pine strips beneath.

The preparation of the rosin squares is usually a very troublesome matter, but becomes easy when the following directions are observed. A clean, flat board, having an area about twice that of the polishing tool, is prepared. One face of this is covered with clean paper. Long strips of wood ¼ inch square are fastened upon the paper by means of fine brads; these strips are placed just 1¼ inches apart, and the ends of the grooves thus formed (grooves 1¼ inches wide, ¼ inch deep, and of any convenient length) are closed with strips of wood. The board is now carefully leveled. The rosin, when melted and softened to the proper degree, is to be poured into these grooves, which serve as molds.

A quantity of rosin sufficient to fill all the grooves is melted in a clean pan. Even when only a small quantity is needed it is best to melt at least ten pounds of rosin, since the entire process of "tempering" and pouring is more easily and satisfactorily carried on with large quantities than with small. Only lumps of clear, clean rosin should be used. A gas or gasoline stove is very convenient for melting the rosin, since the degree of heat can be easily controlled. When the rosin is melted the pan is removed from the stove and a quantity of turpentine, equal in weight to about 1-25 of the rosin used, is added, and the mass thoroughly stirred. A tablespoonful of the liquid is now dipped out and immersed for several minutes in a bucket of water at the temperature of the polishing room, which should be about 68 deg. Fahrenheit. The spoonful of rosin is now taken out, and its hardness tried with the thumb-nail. If the rosin is brittle at the thin edges it is still too hard, and a little more turpentine must be added; if, however, it is soft like wax or gum, it is too soft, in which case the pan of rosin must be hardened by boiling for a few minutes; this drives off the excessive turpentine. When the rosin is of the proper hardness an indentation about ¼ inch long can be made in it by moderate pressure of the thumb-nail for five seconds. When the proper degree of hardness has been obtained it is often necessary to heat the pan of rosin again so that it will not be too thick to pass readily through the strainer; this is a long, narrow bag of cheese-cloth through which the rosin is strained as it is being poured into the grooves or moulds previously described. If such heating is necessary it must be done gently and without boiling; otherwise the rosin will be hardened. Enough is poured into each groove to just fill it.

After being poured, the rosin should cool for six or eight hours. Then the nails which held the quarter-inch strips of wood to the board below are removed, and the layer of rosin, wooden strips, and paper is carefully lifted from the board, when the paper is easily stripped from the rosin, to which it does not adhere closely. With care the thin strips of wood can now be removed, one after the other, and the long strips of rosin, 1¼ inches wide and ¼ inch thick, are secured without chipping or breaking. These are now readily cut into squares with a hot knife.

The squares are attached to the previously marked wooden basis by quickly warming one face of each square over a flame and then pressing it gently against the tool with the fingers. The tool is now ready for rough-pressing.

Three strong eyes are screwed into the back of the tool, and it is suspended face down (by means of wires connected to the ceiling of the room), so as to hang about two feet above the flame of a gas or gasoline stove. The tool can now be swung about so that the rosin squares are warmed uniformly. When the squares are slightly soft and very slightly warm, *but not hot*, to the touch, the tool is placed upon the previously ground glass which is to be polished, the glass having just previously been thoroughly wet with distilled water so that the rosin will not stick to it. Slight pressure may be exerted to assist in pressing the rosin surface to fit the glass. The tool will have to be slightly warmed and pressed several times before good contact is secured all over. I always prefer to "rough-press" the rosin tools on an iron grinding tool having the same form as the glass, if a sufficiently large one is available; but the precaution is always taken to cover the iron tool with clean wet paper.

The rosin squares will have spread somewhat irregularly during the rough-pressing; so the surface is marked with a straight-edge and knife, and the edges of the squares are trimmed so that the grooves between them are straight and of uniform width. This trimming is best done with a sharp knife, held so as to make an angle of about 60 deg. with the surface of the tool, and drawn quickly toward the workman.

The rosin squares are now ready for coating with wax. A pound of the best beeswax is melted in a large, clean cup and is very carefully strained through several thicknesses of cheese-cloth into a similar clean cup. A brush is made by tying several thicknesses of cheese-cloth around the end of a thin blade of wood 1¼ inches wide. Each rosin square is now coated with a thin layer of wax, by a single stroke of the brush; the wax should be very hot, otherwise the layer will be too thick.

The tool is now ready for "cold-pressing" or "fine-pressing," a matter of the most vital importance, which will be more properly described later, in connection with the work of polishing the glass.

The work of making a large concave mirror will now be described in detail.

VI. ROUGH-GRINDING THE FACE AND BACK OF A ROUGH DISK OF GLASS, AND MAKING THE SAME PARALLEL.

The rough disk of glass is placed upon the carpeted turntable, and a long strip of thin oilcloth is drawn around its edge; the upper edge of the oilcloth is securely fastened to the glass by means of a strong cord, and the junction between oilcloth and glass is made water-tight by means of water-proof adhesive tape. The oilcloth strip is wide enough to hang several inches below the edge of the iron plate on which the glass rests, so that the circular trough of galvanized iron, which can be seen in Plates III. and V., catches all of the emery and water which are washed over the edges of the glass during grinding; this circular trough is stationary, has two holes in its bottom above the buckets, which can be seen in the plates, and is kept scraped clean by two scrapers which reach down into it from the revolving turntable. Several important results are thus secured; the carpet cushion under the glass is kept dry; the entire machine is kept perfectly free from the dripping of the grinding material; and all of the latter material is caught in buckets and is used again and again in the later and finer grinding.

The large irregularities of surface of large rough disks are usually ground away with coarse emery and a heavy, flat, half-size iron tool without grooves, the surface of which is rounded up considerably at the edge, so that the tool may rise easily over obstructing irregularities without breaking them. The grinding machine is set so that the half-size tool moves over the glass well out to one side of the latter; the rotation of the turntable of course brings all parts of the glass in succession under the tool; if the setting of the machine is such that the half-size tool passes in much beyond the center of the glass at every stroke, the surface of the latter will become concave.

When the marked irregularities of surface are ground away, the full-size, flat, grooved iron tool is put on. A tool of this kind is almost indispensable in making a mirror. Emery and water are supplied through the cups at the back of the tool, and the glass is quickly ground approximately flat. The glass is now turned over, and the other side is ground in a precisely similar manner.

The thickness of the glass is now tried, all around, by means of calipers. The approximately flat surfaces will probably be found to be far from parallel. If this is the case, the thick side may be ground down as follows: The belt which drives the turntable is loosened, until it will just rotate the latter, and a brake is arranged so that the workman can stop the rotation of the turntable at any desired point by pressing on the brake with his foot. A flat, half-size grooved tool is put on, and set so as to work far out to one side of the glass. A medium grade of emery No. 70) is used, and the machine started. As the thick side of the glass, which has been marked, comes be-

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..th the moving tool, the turntable is slowed down stopped, so that a great excess of grinding is done the thick side at each revolution. By distributing grinding carefully, and trying the thickness often th the calipers, the upper surface is easily made allel to the lower one. When this is done the full-tool is again used for a short time. The glass is n ready for edge-grinding.

..I. GRINDING EDGE OF GLASS.—ROUNDING OF CORNERS.

In order that an efficient edge-support, which will described later, may be given to the glass, it is de..ble that the edge of the latter be ground truly ..ular and square with the face. The manner in ..ich this is accomplished is shown in Plate V. The ..s lies upon three large blocks of wood, which hold several inches above the surface of the circular iron ..e. Thin oilcloth is arranged about the blocks and ..r the iron plate, to keep them dry. A smooth, flat, ..n face-plate is mounted (so as to rotate in a vertical ..ne) on a heavy lathe head-stock; the latter is car..d upon a strong slide which can be moved toward glass by means of a fine pushing-screw. The lathe ..d face-plate are driven at a high rate of speed by ..ans of a belt. In the case of the 5-foot glass the ..e-plate used was 24 inches in diameter and made ..0 revolutions per minute. For a 24-inch glass, 3½ ..hes thick, a face-plate 11 inches in diameter, mak..g 1,800 revolutions per minute, is used. A frame wood, covered with oilcloth, is built around the ..e-plate, so that the grinding materials will not be ..wn about the room. The glass rotates slowly with turntable, as usual. Emery and water, or sand and ..ter, are heaped upon the horizontal surface of the ..s, and are slowly scraped toward and over the ..e, so as to come between the revolving face-plate ..d the glass; a small jet of cold water, brought from hydrant by means of a rubber tube, greatly assists the uniform feeding of the emery, and also in pre..ting the generation of heat. But there is in reality danger of heating, for the revolving face-plate ..er actually touches the glass. As the irregularities the edge are ground away the face-plate is gradually ..ved forward by means of the slide and pushing-..ew.

If the edge of the rough disk be very irregular, as is ..ally the case, the surface of the iron face-plate ..ll have a circular groove worn in it, by the time the ..gh-grinding of the edge is done; in this case the ..e-plate should be turned flat and true again, and ..othed on a flat iron grinding-tool, before the edge the glass is fine-ground. Several fine grades of ..ery are now prepared by the process of washing to described later, and the edge-grinding is finished the use, in succession, of three such grades of emery flour, three-minute washed, and ten-minute washed. ..re should be taken throughout the process that the ..e of the glass is ground square with the face; any ..or in this respect can be corrected by slightly rais..g or lowering the outer end of the slide which sup..rts the lathe head-stock.

Edge-grinding is accomplished very quickly in the ..nner described. The edge of a 24-inch disk four ..hes thick, even when very rough and irregular, has ..en ground and smoothed in ten hours of actual ..nding. Despite the great speed of the rotating ..e-plate, I have never had any chipping of the glass accident of any kind occur.

Before beginning the fine-grinding of the face and ..k it is well to round the corners at the edge of the ..ss. This is done by means of a smooth flat strip of ..et-brass of the size and shape of a large flat file; ..is is worked over the corners of the glass by hand, ..ile the disk rotates slowly, emery and water being ..ed for cutting. A "quarter-round" corner is usually ..de. Finer and finer grades of emery are used for ..oothing the quarter-round. This rounding and ..oothing are very necessary, as particles of glass ..m a sharp or rough edge are liable to be drawn in ..on the surface by the action of the grinding tool ..ring fine-grinding.

The wooden blocks are now removed and the glass placed upon the carpeted turntable.

..I. FINE-GRINDING AND POLISHING THE BACK OF THE MIRROR.

Before discussing the work of fine-grinding I shall ..scribe briefly the making of the fine grades of ..ery. I never buy finer grades than "flour." The ..tter grade is used with the full-size flat grooved tool give a moderately fine surface to the glass after ..e rough-grinding previously described has made the ..nt and back approximately flat and parallel. The ..sidue of emery, fine ground glass, and water, result..g from the grinding with flour emery, is caught in ..ckets, as previously described. This residue is ..xed with an abundance of water, in (for a large ..rror) three or four clean granite-ware buckets, ..ich are marked *A*. The contents of these buckets ..e thoroughly stirred, and are allowed to settle for ..o minutes; during this time all coarse particles will ..ve settled to the bottom, and "two-minute" emery ..d finer grades remain in suspension in the water. ..e liquid is now quickly siphoned off, by means of a ..bber tube, into other clean granite-ware buckets ..rked *B*, from which the handles have been removed. ..e contents of the latter are allowed to settle for ..ur minutes, when the greater part of the liquid in ..ch is carefully poured back into the buckets, *A*. ..e contents of the latter buckets are reserved. The ..diment remaining in the buckets, *B*, is the "two-..nute" washed emery, with which the fine-grinding the back is begun. After the grinding with this ..de is finished, the residue from this grinding is mixed with what was reserved in the buckets, *A*, the whole is stirred again and allowed to settle for five minutes, the liquid is siphoned off, and thus "five-minute washed" emery is secured. In a similar manner emeries which have remained in suspension for 12, 30, 60, 120, and 240 minutes are secured. In this way the larger quantities of the finer grades which are necessary for large work can be secured as the work progresses. If accumulations of residues from previous work are available, some time will be saved by washing out all of the finer grades desired before the fine-grinding is begun.

Plane and concave mirrors are finished approximately flat on the back, as this form is most convenient for the application of the support-system. Fine-grinding of the back is usually done with the full-size, flat grooved tool, as this works rapidly. In this part of the work, in which the greatest refinement is not necessary, it is my custom to use the fine grades of emery (when these have all been prepared in advance) in succession, without stopping the machine or taking off the tool between grades for the purpose of cleaning the tool and the glass. The emery and water are supplied through the wooden cups at the back of the tool.

For a 24-inch mirror and its full-size tool, strokes varying from 6 to 8 inches in length are used with the 2, 5, and 12-minute washed emeries; shorter strokes, from 4 to 6 inches in length, are used with the finer grades. Considerable lateral displacement of the tool, amounting at the greatest to 2 or 2½ inches on the glass, is given at short intervals, by means of the transverse slide. On an average 20 double strokes per minute are given in fine-grinding a 24-inch mirror with full-size tool. Between 7 and 8 double strokes occur for each revolution of the glass and turntable.

With regard to counterpoising the tools during fine-grinding, the following statements may be made: My full-size iron tools for a 24-inch mirror weigh about 150 pounds, or 1-3 pound for each square inch of area. This weight, or even ½ pound to the square inch, is not objectionable with emeries down to 5-minute or 10-minute washed; but when this weight is allowed with finer emeries, scratches are liable to occur; indeed, with 30-minute washed and all finer grades they are almost certain to occur. The pressure on the glass is therefore decreased, by counterpoising the tool, to approximately 1-5 pound to the square inch for 12 to 20-minute emeries, ¼ pound per square inch for 30 to 60-minute emeries, and about 1-12 pound per square inch for 120 and 240-minute emeries. This rule is followed, approximately, in all fine-grinding, whether of back or face. This obviates, to a great extent, the danger of scratches in grinding, provided that thorough cleanliness is practised in the preparation and use of the fine emeries. The apparatus by which the counterpoising is effected has already been described.

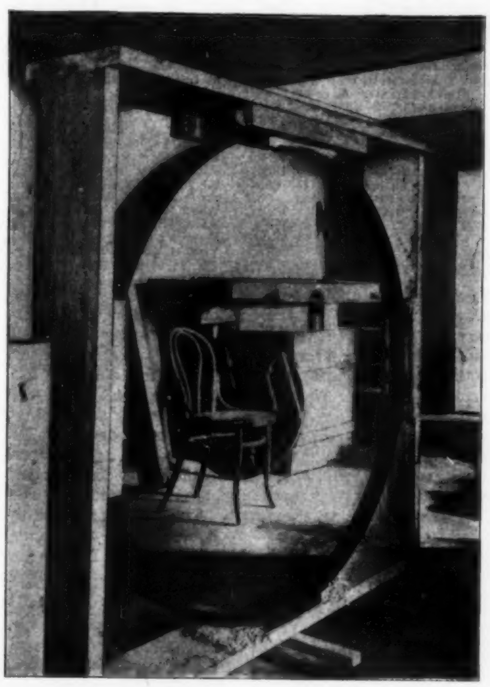

PLATE VI.—FIVE-FOOT MIRROR WITH FRONT AND BACK POLISHED APPROXIMATELY FLAT, LOOKING THROUGH THE GLASS.

In fine-grinding a 24-inch glass, the 2-minute and 5-minute emeries are used for three-quarters of an hour each; the 12 and 30-minute emeries for one hour each, and the 60, 120, and 240-minute emeries for one and one-half hours each. The fine-ground surface resulting is so exquisitely smooth that it takes a full polish very readily.

The back of the glass is now ready to be polished. This is done with a half-size or two-thirds size polishing tool, which is moved about on the glass by the action of the machine precisely as a half-size grinding-tool would be. Optical rouge and distilled water are used, instead of emery and water. The work of polishing will be described in detail later, in connection with the work of finishing the face of the glass.

It is an excellent plan to fine-grind and polish the front surface of a disk also, approximately flat, as has been described for the back; the optician is then able to examine carefully the internal structure of the disk. Usually there is no choice as to which side shall be used for the face of the mirror, but this can readily be determined when both sides are polished. Plate VI. shows the 5-foot disk with both sides ground and polished in this manner.

IX. GRINDING THE CONCAVE SURFACE.

As before stated, it is my practice to use full-size grinding tools for concave mirrors up to 24 or 30 inches in diameter. For larger concave mirrors half-size tools are generally used. I shall first describe the grinding of a 24-inch concave.

The glass must be carefully centered by means of the three adjustable arcs attached to the supporting plate; these arcs must not be screwed tightly against the glass, lest the latter be strained; several thicknesses of heavy drawing paper are used between arcs and glass.

The glass must also be carefully leveled (by means of the three large adjusting screws of the turntable) so that its upper surface is accurately at right angles to the axis of rotation; this is determined by rotating the turntable, and trying the surface with a surface-gage. The band of thin oilcloth is securely bound around the edge of the glass, to keep the polished back and the cushion clean and dry.

The excavation of the concave is begun with moderately coarse emery (if the concave is to be quite deep) and a lead tool; this is a lead disk about 10 inches in diameter and 1½ or 2 inches thick; it is easily turned in a lathe to the proper curvature; it is used on and near the center of the glass until a depression of approximately the desired curvature (as determined by the spherometer) and of 12 or 13 inches diameter is produced. A heavy iron tool about 13 inches in diameter, which has been turned and ground to the proper curvature, is now put on with about No. 90 emery. By giving careful attention to the length of stroke, and to the position of the tool on the glass as determined by the setting of the transverse slide, and by frequent trials of the curvature of the excavation with the spherometer, the diameter of the excavation is gradually increased, while its curvature is continually kept very near that which is desired for the finished mirror; this keeps the iron tool of proper curvature also.

The stroke used in this work should vary from 6 to 10 inches in length. As the size of the excavation increases, the setting of the transverse slide is continually changed so that the tool acts farther and farther to one side of the center of the glass; otherwise the radius of curvature will be shortened. When the diameter of the excavation has increased to about 22 inches, flour emery is substituted for the No. 90, and the grinding is continued as before. Care is now taken to make the curvature read exactly right with the spherometer. When the excavation becomes about 23 inches in diameter, the 13-inch tool is taken off, and the full-size, convex, grooved iron tool is put on; this has previously been fine-ground to the proper curvature on the corresponding concave tool. With this tool and washed flour emery the diameter of the concave on the glass is increased to 23⅝ or 23¾ inches.

The fine-grinding or smoothing of the concave is now done with the full-size tool. The same grades of emery, the same lengths and speed of stroke, and the same rules in regard to counterpoising are used as have already been described in the case of fine-grinding the back of glass. The length of stroke is changed every eight or ten minutes, and the lateral displacement of the tool (given by means of the transverse slide) is changed slightly at the end of every two or three complete revolutions of the glass. The tool is taken off after each grade of fine emery is used, and the tool and glass are carefully cleaned. With the assistance of the counterpoise lever the removal of the tool is effected easily and safely, without disconnecting it from the main arm of the machine; this is well shown in Plate III., in which the grinding tool is shown hanging at one side of the glass.

The surface of the glass is examined with a microscope after each grade of emery is used, to make sure that no pits from previous grades remain.

During all fine-grinding and machine-polishing a large sheet of heavy clean paper or pasteboard is attached to the main arm in such a way that no particles of dust from the belts which control the slow rotation of the tools can fall upon the glass.

The process of grinding larger concave surfaces without the use of full-size tools is precisely similar to that described for a 24-inch mirror, up to the point of substituting the 24-inch convex tool; from this point the grinding is carried on by a continuation of the use of a half-size, convex grooved tool; this may be the same iron tool which has been used for enlarging the excavation. When the diameter of the excavation approaches that of the glass, the tool should be tested with the spherometer for curvature, and, if necessary, ground in its corresponding concave iron tool until its curvature is uniform and of exactly the desired radius. The grinding of the glass is then continued with washed flour emery until the edge of the excavation is within ¼ inch of the edge. Experience in the previous use of the half-size tool, in enlarging the excavation and in keeping the curvature of the glass uniform and of the desired radius, will enable the optician to decide upon the various lengths of stroke and the various settings of the transverse slide necessary in this grinding and in the finer grinding to follow.

In fine-grinding a 30-inch concave with a 16-inch tool, strokes varying from 6 to 12 inches in length are used; for a 9-inch stroke the normal setting of the transverse slide (i. e., one which would tend neither to lengthen nor shorten the radius of curvature of the glass) would be such that the outer edge of the tool overhangs the glass about 3 inches in the forward stroke, while the inner edge of the tool passes about one inch on the other side of the center of the glass on the return stroke.

Throughout the entire process of fine-grinding with the half-size tool the length of stroke is changed once every eight or ten minutes; at the end of every two or three revolutions of the glass the setting of the transverse slide is changed, a little at a time, for a considerable distance on either side of the normal setting; the setting of the slide can be changed without difficulty, while the machine is running, by merely turning a hand-wheel. By these means the formation of zones of unequal focal length can be entirely avoided.

The same grades of emery are used, and the same rules in regard to counterpoising observed, as with full-size tools. Notwithstanding the fact that the length of stroke can be considerably greater than with full-size tools, each grade of emery must be used for a longer time, on account of the smaller area of the grinding surface. Glass and tool are thoroughly cleaned, and the surface of the former examined, after the use of each grade of emery, as before described.

Care must be taken during this work that the belts which rotate the turntable are kept tight, so that no irregularity in the rotation of the turntable with reference to that of the crankshaft can occur. It is absolutely necessary that all of the fine work on large mirrors be done in rooms where no sudden changes of temperature can occur, and that nothing be allowed which might affect the temperature of the glass locally.

If the concave mirror is intended for a paraboloidal one, the fine-ground surface should be spherical, with its radius of curvature $2F + \frac{R^2}{4F}$, where F is the desired focal length of the finished paraboloid and R is the semi-diameter of the mirror; the reason for this is fully explained later. I have never attempted to parabolize while fine-grinding; it is possible that it might be well to do this in the case of very large mirrors of short focus, but my practice has been to fine-grind and polish to a spherical surface, free from zones, and then to parabolize by means of suitable polishing tools.

(To be continued.)

[Continued from SUPPLEMENT No. 1511, page 24210.]

EXPERIMENTAL ELECTROCHEMISTRY.*

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THIRD PAPER.

The Theory of Electrolytic Dissociation.

IT is well known that pure water freezes constantly at 0 deg. C., and that this fact has been made the basis for the several thermometric scales for scientific purposes throughout the world. It has also been well known from very early times that the addition of salts or other soluble material to water causes it to freeze at a lower temperature. Every schoolboy knows that common sea-water will not freeze except at very low temperatures, but few of us who have not paid attention to physical chemistry, have given the fact more than a passing thought. We know that substances in solution cause pure water to freeze at a lower temperature than pure water alone, in other words, that the freezing point is lowered by the presence of dissolved substances. This is purely qualitative knowledge, so to speak, and there remains for us to investigate this matter quantitatively, to see how much solutions of the same concentration lower the freezing point, and if all compounds lower it equally. Raoult, the celebrated French chemist, took up this matter for experimental investigation, and to make a long story short, found that all non-electrolytes, of equal concentration, lowered the freezing point of pure water to the same extent. Raoult worked with solutions containing one gramme-molecule of the dissolved substance per liter and found that the lowering of the freezing point was the same, being 1.85 deg. C. One gramme-molecule of a substance per liter is a normal solution, and we may say therefore, that all normal solutions of non-electrolytes lower the freezing point of water 1.86 deg. C. This is comparable to saying that the lowering of the freezing point of pure water is dependent upon the number of molecules or ultimate parts of molecules present. This is, of course, an interesting fact, but what has it to do with the theory of electrolytic dissociation? This question can be very quickly answered by determining the lowering of the freezing point by normal solutions of electrolytes. What would we expect if the theory of electrolytic dissociation is true? Will a gramme-molecule of an electrolyte dissolved in a liter of water give us the same depression of the freezing point, namely, 1.86 deg. C.? This was done by Raoult and it was found that *in every case of an electrolyte the depression of the freezing point was greater than 1.86 deg. C.* It will be remembered that all electrolytes exerted a greater osmotic pressure than non-electrolytes, and now we see that all electrolytes lower the freezing point to a greater extent than non-electrolytes. We can only account for these striking phenomena by attributing the abnormal behavior of electrolytes to the breaking up of the molecules upon dissolving, into ions. The practical student, upon reading the work done by Raoult and noting his constant of 1.86 deg. C., will want to know how much greater the depression of the freezing point was found to be in the case of electrolytes, and what kind of a thermometer was employed when we are dealing with such small differences in temperature. The average electrolyte, when dissolved in water, depresses the

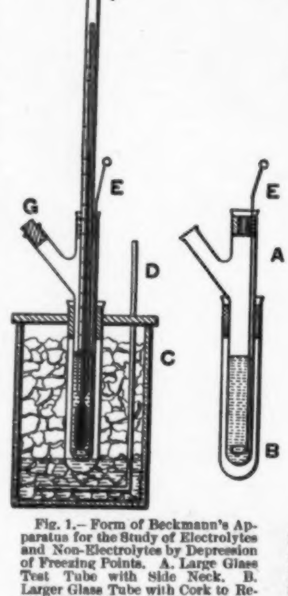


Fig. 1.—Form of Beckmann's Apparatus for the Study of Electrolytes and Non-Electrolytes by Depression of Freezing Points. A. Large Glass Test Tube with Side Neck. B. Larger Glass Tube with Cork to Receive Test Tube. C. Large Glass Jar to Receive Both Tubes and Freezing Mixture. D. Stirrer. E, E. Wire Stirrers Within Test Tube. G. Side Neck into which the Substance to be Tested is Placed. F. Delicate "Open Scale" Thermometer.

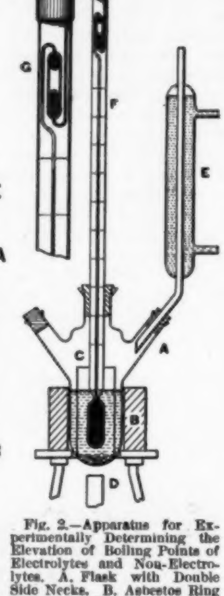


Fig. 2.—Apparatus for Experimentally Determining the Elevation of Boiling Points of Electrolytes and Non-Electrolytes. A. Flask with Double Side Necks. B. Asbestos Ring Supporting Flask on Tripod. C. Little Cylinder of Platinum Within Flask to Prevent Cooled Condensed Water from Striking the Thermometer Bulb. D. Bunsen Burner. E. Condenser with Water Jacket. F. Beckmann Thermometer with Mercury Reservoir at Top. G. Enlarged View of Mercury Reservoir.

freezing point about twice as much as any non-electrolyte. As for the thermometer, it is far from ordinary pattern, and is used in a special piece of apparatus. The best and most universally used apparatus is that of Beckmann, and is illustrated in one of its forms in Fig. 1. The thermometer in this particular case is simply one of great sensitiveness and refinement, reading direct to hundredths of a degree. Because of an exceptionally large bulb, the degree divisions are very long, allowing of such fine subdivision. With such a thermometer one-tenth of one degree Centigrade is a large amount. The accompanying illustration should make the scheme of the apparatus

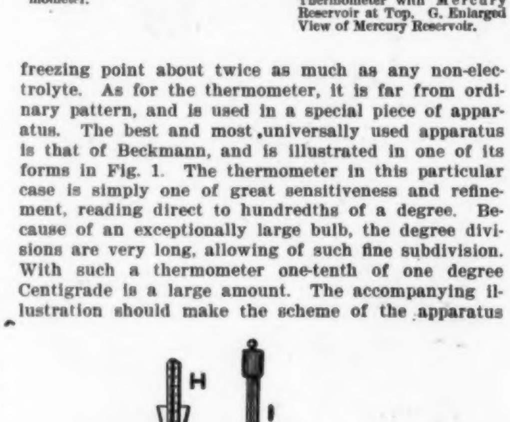


Fig. 3.—Calorimeter for Measuring the Heat Liberated when Solutions of Electrolytes are Mixed Together and Allowed to React. A. Brass Calorimeter Casing Containing Mass of Water, B. There is Also an Inner Calorimeter Casing of Polished Metal, C, and the Reaction Chamber, D. E. Hair Felt Covering. F. Stirrer. G. Glass Reservoir with Stopcock. H and I. Two Similar Thermometers of Sensitive Type Reading to Hundredths of a Degree. J. Thermometer Indicating Temperature of Water Jacket. K. Wooden Wedges to Insulate Calorimeter.

clear, and it will be seen is a simple one to get up in the laboratory for actual work, the thermometer being the only costly element. For exceedingly accurate research work such thermometers may be had reading to thousandths of a degree. There are also metallic thermometers with which temperatures are measured by the change in electrical resistance of a little coil of platinum wire, and the delicacy is almost without limit. For all practical purposes, however, a mercury thermometer reading to hundredths meets every requirement. The practical carrying out of an experiment with such a piece of Beckmann's apparatus as shown in Fig. 1 is as follows: An accurately weighed quantity of pure distilled water is introduced in the tube A, which in turn is placed in the tube B, and packed around with a mixture of ice and salt. The large tube B provides an air space around the tube A and causes a more uniform freezing of the water in the inner tube. The air between the two tubes becomes chilled below the freezing point of pure water of course, and freezes the water in the inner tube. The little stirrer E is moved up and down in the distilled water, and the thermometer is carefully watched. The mercury will fall steadily until the sudden formation of little flakes of ice throughout the water, when it will quickly rise a little and remain stationary, and this reading should at once be taken. With a correct thermometer, the indication should of course be 0 deg.

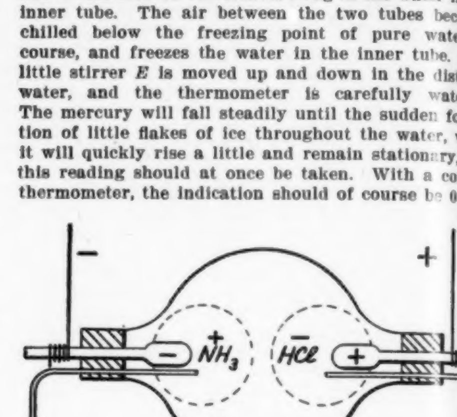


Fig. 4.—Diagram Representing an Uncombined Mixture of Dry Ammonia Gas and Dry Hydrochloric Acid Gas. The Respective Gases are here being Separated by Charged Electrodes, where they may be Drawn off and Tested.

C. If the reading is not exactly 0 deg. it matters not so long as we are merely measuring the differences between the freezing point of pure water and water containing compounds in solution. At least three readings should be made with the same water, allowing the ice to melt, and then freezing over again, and taking the average of the three temperatures for the freezing point of the pure solvent. The little sudden rise of the thermometer is due to a small super-cooling of the water (in spite of the fact of its being stirred) below its freezing point, and then its warming up again at the instant of the formation of ice. It is well known to those of us who have studied physics, that water throws off heat when it freezes, and is attributed to latent heat. Having determined carefully the experimental freezing point of the water, a carefully weighed quantity of the substance to be tested is introduced through the side tube D, and allowed to dissolve. The freezing process is then repeated three times, as with our pure water, and the average of the three readings is taken. If our water and compound have been so weighed as to give us a normal solution, and our compound is a non-electrolyte, we will obtain the figure 1.86 deg., working of course with a Centigrade thermometer. The important point to observe in making all these freezing point determinations, is to read the thermometer at once after the little sudden rise of the thermometer, at the time of the formation of the ice. If we wait, and keep on with the freezing process, the

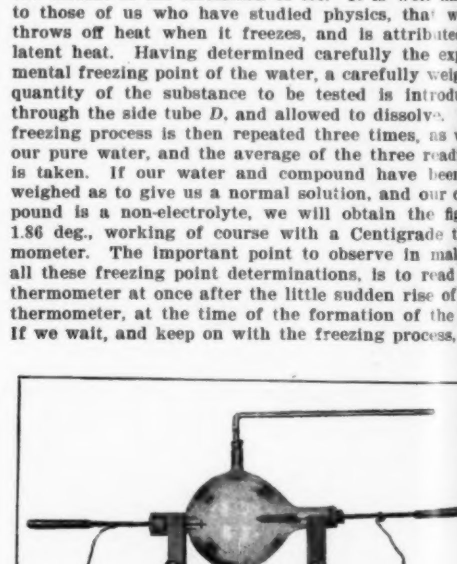


Fig. 5.—Glass Globe with Electrodes Leading to Static Machine for Separating a Perfectly Dry Mixture of Ammonia and Hydrochloric Acid Gases. After Mixing Together in the Globe the Gases May be Separated by Static Charges Upon the Electrodes and be Drawn Off Through the Glass Tubes.

thermometer will fall again, due to the fact that our solution has become concentrated by the freezing out of some of the water. This, of course, concentrates the solution, and gives it a new and lower freezing point. Electrolytes are treated in the same manner of course as non-electrolytes. There is another method which we should not pass over without notice, and that is the testing of electrolytes and non-electrolytes by the elevation of the boiling point. It is also well known that pure water boils at a constant temperature

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

under a constant atmospheric pressure, and that the heights of mountains have been measured by the decrease in boiling point of water with a delicate thermometer. It is also very well known that the presence of dissolved substances increases the boiling point of pure water. Raoult also investigated this phenomenon experimentally, and found that normal solutions of non-electrolytes increased the temperature of the boiling point to the same extent. He also showed that all electrolytes of comparable concentration, elevated the boiling point to a much greater extent. Fig. 2 illustrates a piece of apparatus for experimentally determining the elevation of boiling points with great accuracy. This special type of thermometer has an arbitrary scale, that is, it is not designed to indicate absolute temperatures, but only differences between temperatures. The little reservoir at the top contains a supply of mercury, which may be shaken down to join in to the column within the bore, thus allowing the instrument to be used with liquids of lower boiling points. There are only about eight degree divisions upon the entire scale of such a delicate instrument, and were it not for the flexible character due to the little mercury reservoir, the use of such a thermometer would be exceedingly limited. With a set of two such instruments, one designed for low temperatures and the other for high temperatures, in view of the little reservoirs, we are equipped for experimental work throughout a very wide range. With either thermometer we may take from the reservoir, or return to the reservoir, by shaking the instrument, thereby making it serviceable for use at almost any temperature. In conducting experiments with this apparatus, a few fragments of broken glass are introduced in the little flask to prevent "bumping" when the solution boils. We see, therefore from these two experimental investigations of Raoult, that we have the most excellent evidence in favor of the theory of electrolytic dissociation.

Additional Evidence—The Neutralization of Acids and Bases.

One of the commonest and most familiar chemical reactions is the neutralization of an acid by a base with the formation of salt and water. The following is a simple example, where hydrochloric acid and sodium hydroxide are brought together in solution:

$$H\,Cl + Na\,OH = Na\,Cl + H_2O.$$

Here we have sodium chloride (common salt) and water formed in the reaction. So much for the general chemistry of the reaction. We also have a physical side to the reaction, and this concerns the heat produced when the reaction takes place. The general chemist has to do with the products formed, and the physical chemist has to do with the energy transformations and their measurement. Now in the above reaction heat is formed, and it remains for us to determine how much, and to see if it has anything to do with our theory of electrolytic dissociation. Let us carry on such a chemical reaction, and experimentally measure the amount of heat given out. For this purpose we shall require a calorimeter like that represented in Fig. 3. It is easily made of polished brass by any good sheet-metal worker, and is a valuable piece of apparatus for the physical-chemical laboratory. The inner reaction chamber *D* should be of thin platinum, however. For our experiment we will place a normal solution of sodium hydroxide within the platinum chamber, and a normal solution of hydrochloric acid within the glass reservoir with the stopcock turned off. The two thermometers are inserted, and the entire apparatus is allowed to stand for a sufficiently long time to allow equilibrium to be established. The thermometers are then read, and the hydrochloric acid from the reservoir is allowed to run into the calorimeter while the stirrer *F* is operated. The thermometer *I* is carefully watched until the mercury rises to the highest point. Now we are to measure the heat of the reaction in calories, and in order to do this it is only necessary to know the mass of the liquid raised through the indicated temperature, and to make the usual calorimetric corrections. We must know and allow for the specific heat of the mixture, the weight and specific heat of the platinum vessel, the heat exchange of the calorimeter, etc. The detailed method of working with calorimeters can be found in any good laboratory treatise on general physics. As a result of such an experiment with hydrochloric acid and sodium hydroxide, we get 13,700 calories, in addition to the formation of the salt and the water. Now to come to the point, it matters not what acid and what base we use, or what salt is formed, we always get experimentally in such a calorimeter determination, 13,700 calories. The following table indicates the run of things, and it now remains for us to interpret the meaning, and to see what it has to do with electrolytic dissociation. The first table gives a varying acid and a constant base, and the second table a varying base and a constant acid.

$H\,Cl + Na\,OH$ liberates 13,700 calories.
$H\,Br + Na\,OH$ liberates 13,7·0 calories.
$H\,I + Na\,OH$ liberates 13,700 calories.
$H\,NO_3 + Na\,OH$ liberates 13,700 calories.

$H\,Cl + Li\,OH$ liberates 13.700 calories.
$H\,Cl + K\,OH$ liberates 13,700 calories.
$H\,Cl + Ba\,(OH)_2$ liberates 13,800 calories.
$H\,Cl + Ca\,(OH)_2$ liberates 13,900 calories.

In the case of the calcium and barium hydroxides, one-half normal solutions were taken to normal solutions of hydrochloric acid, for the reason that calcium and barium are bivalent. The above tables exhibit to us a remarkable performance, and it remains for the physical chemist to explain it. The theory of electrolytic dissociation explains it perfectly, and in so doing gains important experimental evidence in its own support.

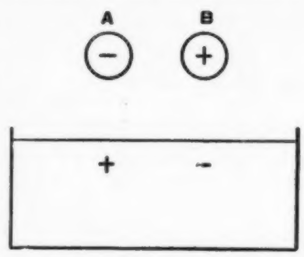


Fig. 6.—Diagram Illustrating the Part Played by a Dissociant when an Electrolyte is Immersed. A and B are the Atoms of a Molecule.

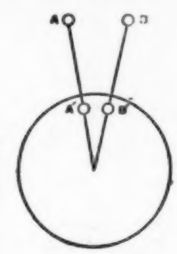


Fig. 7.—Diagram Illustrating Prof. J. J. Thompson's Theory of Electrolytic Dissociation, Assuming that the Atoms in a Molecule are Held Together by Electrical Attraction.

$H\,Cl$ and $Na\,OH$ react and give $Na\,Cl$ and H_2O.

In terms of our theory, however, these bodies would be dissociated, and represented thus:

$\overset{+}{H}\ \overset{-}{Cl}$ and $\overset{+}{Na}\ \overset{-}{OH}$ react and give $\overset{+}{Na}\ \overset{-}{Cl}$ and H_2O.

Salt and water are the products, of course, but as the salt is born in water, so to speak, it is dissociated as represented $\overset{+}{Na}\ \overset{-}{Cl}$, and not as $Na\,Cl$, as it would be out of solution. The only thing really formed in the molecular state is water, and the constant of 13,700 calories is merely the heat of formation of water. All bodies have either a positive or a negative heat of formation, and if the salt is formed in the molecular condition along with the water, it would, of course, add its own heat of formation to the sum total, and as different salts have different heats of formation, we would, of course, not get a constant, but a different number of calories for each reaction between an acid and a base. The following table gives the heats of formation of a number of salts produced by the acids and bases which we have tabulated:

$Na\,Cl$	9760 calories.
$Na\,Br$	8580 calories.
$Na\,I$	6910 calories.
$Na\,NO_3$	11130 calories.
$Li\,Cl$	9380 calories.
$K\,Cl$	10430 calories.
$Ba\,Cl_2$	19470 calories.
$Ca\,Cl_2$	16980 calories.

In the case of the calcium and barium chlorides, one-half the indicated number of calories must be taken, for the reason that calcium and barium are bivalent, and require double the quantity of acid.

It will thus be seen that without the theory of electrolytic dissociation, we would be unable to explain the liberation of a constant number of calories, when an acid reacts with a base.

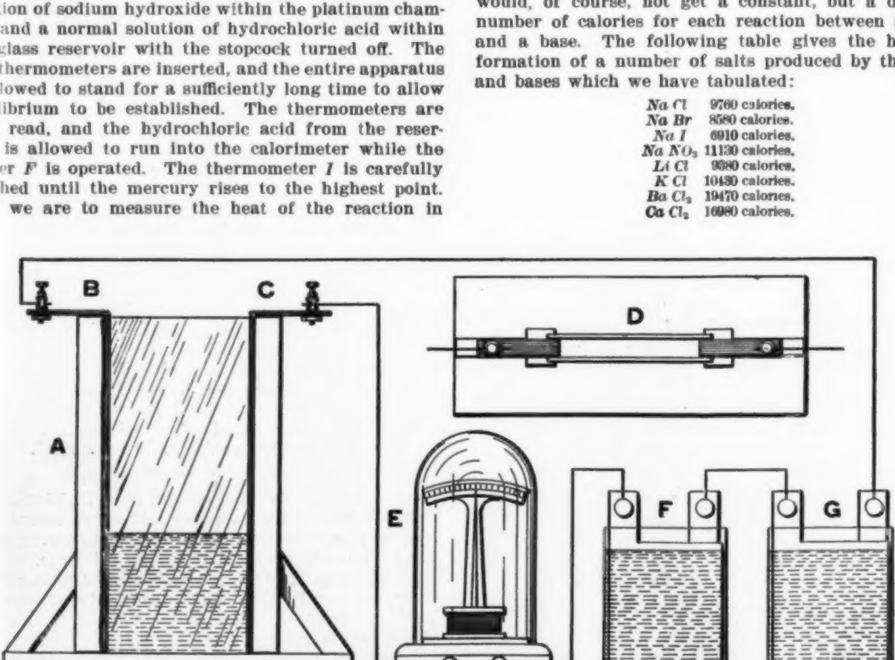


Fig. 8.—Practical Experiment to Show Electrolytic Dissociation Simultaneously in Two Ways. A. Narrow Tank with Wooden Ends and Glass Sides. B and C. Electrodes Reaching to Bottom. D. View of Tank Looking from Top. E. Galvanometer in Series with Electrodes and Storage Cells, F and G. The Lamp Bank Described in Chapter I May Well Take the Place of the Storage Cells.

Additional Evidence.

Let us take four electrolytes, for example, and make two mixtures. For this purpose we will choose

First mixture.	Potassium nitrate	$K\,NO_3$
	Sodium iodide	$Na\,I$
Second mixture.	Potassium iodide	$K\,I$
	Sodium nitrate	$Na\,NO_3$

Dilute solutions of both salts in each mixture are represented as follows, with all the constituents dissociated:

$$\overset{+}{K}\ \ \overset{-}{NO_3}\ \text{and}\ \overset{+}{Na}\ \ \overset{-}{I}$$

$$\overset{+}{K}\ \ \overset{-}{I}\ \ \text{and}\ \overset{+}{Na}\ \ \overset{-}{NO_3}$$

In terms of the theory of electrolytic dissociation, we have exactly the same ions present in both cases, and the properties of the two mixtures should be absolutely the same. The two solutions, when equivalent quantities of the different substances are taken, are identical in every respect.

Further Evidence—Experiments with Perfectly Dry Compounds.

Let us take any of the "chemically active" bodies, or electrolytes, and inquire into their behavior when perfectly dry. In terms of the theory of electrolytic dissociation, dry electrolytes are in the molecular condition and are also "chemically inactive." In terms of the theory, the dissociation products, or ions alone, are capable of entering into chemical combinations. Let us test this matter carefully by referring to a number of experiments involving the careful drying of the substances employed. It is well known to the general chemist that ammonia gas NH_3 and hydrochloric acid gas $H\,Cl$ react at once to form ammonium chloride $NH_4\,Cl$.

$$NH_3 + H\,Cl = NH_4\,Cl.$$

The white clouds of ammonium chloride are even manifested when an ammonia bottle is unstoppered in the neighborhood of hydrochloric acid. It has been shown by the most careful and patient workers that thoroughly dry ammonia gas and thoroughly dry hydrochloric acid gas do not react to form ammonium chloride, and may be separated after mixing in a thoroughly dry receiver. The accompanying illustrations show how this may be accomplished after the gases have been produced and thoroughly dried. The absolute drying of these gases is a difficult and tedious process, for the slightest trace of moisture in either the gases or the glass globe will defeat the object of the experiment. They may, of course, be dried by passing through towers of finely-broken lime and phosphorous pentoxide. The globe must be heated to a high temperature by means of a Bunsen flame, while thoroughly dried air is passed through. In every detail, the most elaborate precautions must be taken against having moisture present. In this case we have two molecules NH_3 and $H\,Cl$ behaving like ions, that is, the one goes to the positive pole, and the other goes to the negative pole. The student may ask how it is that we have hydrogen going to the positive pole, as in the $H\,Cl$ diagramatically represented within the globe in Fig. 4. If he will turn to the first chapter, and examine the elements arranged in their "electrochemical order," he will note that chlorine is much more strongly electronegative than hydrogen is electro-positive, and being linked to the hydrogen, draws it to the positive pole. In the case of the ammonia, we may think of the hydrogen winning, and dragging the nitrogen to the negative pole, because there are three hydrogen atoms to the one of nitrogen in the ammonia molecule. Nitrogen is more strongly electro-negative than hydrogen is electro-positive, as can be readily seen from the table, but there are three hydrogen atoms pulling the one nitrogen atom, and we may compare matters to a game of football where three players for one goal get hold of a single player for the other goal. The single player is pulling harder than any one of the others to make his goal because he is stronger, but is merely overpowered in number. So much for this experiment. The following list represents work done by various careful experimenters in support of the dissociation theory:

Perfectly dry sulphuric acid has been shown not to act on perfectly dry metallic sodium!

Dry hydrochloric acid does not act on carbonates.

Dry hydrogen and chlorine may be mixed together and exposed to the sunlight without an explosion taking place.

Dry hydrochloric acid gas does not precipitate silver nitrate from water-free ether or benzine solution.

Dry acids will not act upon litmus paper, and will not form salts with dry bases.

Absolutely dry oxygen gas will not support combustion in many moisture-free substances!

Dry chlorine does not combine with metals, not excepting sodium and potassium.

Absolutely dry gunpowder could not be ignited!!

Allow the slightest trace of water vapor to enter the field in any of the above cases, and we have immediate reactions. What part does the water play? In terms of our theory it is the dissociant, or cause for breaking down the molecules. Fig. 6 represents a molecule consisting of the atoms *A* and *B*, with the "chemical affinity" between them assigned to electrical attraction of unlike charges. The atoms in the molecule here are believed to be held together by electrical attraction. Now bring such a molecule into the presence of water. The negative atom will induce a positive charge in the water, and the positive atom will induce a negative charge in the water. Now, according to J. J. Thompson, one of England's most distinguished and famous physicists, because of these induced charges the attraction between the atoms *A* and *B* will be weakened, and when immersed in the water, will be lost altogether. The following are Prof. Thompson's words when such a molecule as represented in *A B* in the little diagram Fig. 7 is brought near a conducting sphere: "Thus let *A B* represent two atoms in a molecule, placed near a conducting sphere, then the effect of the electricity induced on the sphere by *A* will be represented by an opposite charge *A'*, the image of *A* in the sphere. If *A* is very near the surface of the sphere, then the negative charge at *A'* will be very nearly equal to that of *A*. Thus the effect of the sphere will be practically to neutralize the effects of *A*; as one of these effects is to hold the atom *B* in combination, the affinity between the atoms *A* and *B* will be almost annulled by the presence of the sphere. Molecules condensed on the surface of the sphere will thus be practically dissociated. The same effect would be produced if the molecules were surrounded by a substance possessing a very large specific inductive capacity. Since water is such a substance, it follows, if we accept the view that the forces between the atoms are electrical in their origin, that when the molecules of a substance are in aqueous solution, the forces between them are very much less than they are when the molecule is free, and in a gaseous state."

Now we have considered only solutions of electrolytes in water. Water has therefore been the dissociant in all the cases which we have so far met with. Although water is the strongest dissociant known, there are other liquids capable of breaking down molecules when solutions are made in them. By strongest dissociant known, we mean a solvent which breaks the largest number of molecules down into ions per unit of solvent volume. In very concentrated solutions of electrolytes we have a mixture of molecules and ions. As the dilution is increased the number of ions increase, for upon the addition of more water more of the molecules are broken down. The strong acids, bases, and salts are completely dissociated when a gramme-molecular equivalent is dissolved in 1,000 liters of water. If we dissolve a gramme-molecular equivalent of a strong acid in 500 liters of water, we will have in solution molecules and ions. The solution conducts the electric current solely by the transport of the electricity by the free ions. If we measure the conductivity of such a solution, we will, of course, obtain a certain conducting value. Now, what will be the effect of diluting the solution with water? With further dilution we get increased ionization up to the point where there are no molecules left, all having broken down into ions. We should expect the molecular conductivity of the solution to increase upon diluting with water, if the dissociation theory is true. *As a matter of fact, the molecular conductivity does increase up to the point where we have a gramme-molecular equivalent dissolved in 1,000 liters of water.* Now, water being the strongest dissociant known, all other solvents must be present in larger quantity to effect an equal dissociation. We will now give a table with the dissociants in order of their strength, and follow it by an easily performed practical experiment to show that dissociation increases upon dilution.

Dissociants in Order of Power.

Water.
Formic acid.
Methyl alcohol.
Ethyl alcohol.

There are other dissociants, but the above are among the most common and generally employed. J. J. Thompson has also shown that the dissociating power bears a relation to the dielectric constants. This is in support of the theory of the electrical attraction between the atoms in a molecule. Having stated that dissociation and electrical conductivity increase upon dilution up to a point where we have the gramme-molecule dissolved in 1,000 liters of water, we will now test it by experiment.

Practical Experiment to Show Dissociation and Increase in Electrical Conductivity upon Dilution with Water.

In the following experiment there is developed a double and simultaneous indication of ionization, the appearance of a deep red color on the one hand, and the steady increase of electrical conductivity, upon the addition of water, on the other hand. The color change is dependent upon the well-known behavior of phenolphthalein as a chemical indicator. To the characteristic color deportment of this interesting compound, the conductivity method is simultaneously applied. The experiment as heretofore exhibited consisted in merely the color change which is produced as follows. A small quantity of phenolphthalein is dissolved in ethyl alcohol and is poured into a tall glass lecture jar to a height of about five centimeters. A few drops of ammonia water are then carefully added. There will be a slight momentary yellow coloration, which will immediately disappear upon shaking a little, if too much ammonia water has not been added. If too much ammonia has been added, add more alcohol. Now, we know as general chemists that a colorless solution of phenolphthalein turns a beautiful red in the presence of a base. Here we have the phenolphthalein and the base, ammonium hydroxide, in alcoholic solution together, and no red color appears. Why? Ammonium hydroxide cannot show its basic properties until dissociated into the ions $\overset{+}{NH_4}$ $\overset{-}{OH}$, the isolated *OH* or hydroxile producing such basic manifestations. Now, if we look at the little table of dissociants, we see that ethyl alcohol is a very poor dissociant and is unable to break the ammonium hydroxide molecules down into ions. Now, what will happen if we add some water? Water, as will be seen from the table, heads the list as the strongest dissociant known, and we should expect it to ionize the ammonium hydroxide molecules if it is added. If the ammonium hydroxide molecules are dissociated, or ionized, we should expect the red color of the phenolphthalein to appear and become deeper and deeper as the molecules are broken up into active ions. This is just what happens. Upon the addition of water the color begins to appear, and continues to get deeper and more decided as dilution continues. This is an odd sight, to see the addition of pure water to a faintly-colored solution produce a deeper and deeper color as dilution goes on. So much for the color indication of dissociation on dilution. Now, molecules do not conduct the electric current, and it occurred to the author to perform this same experiment over again, but instead of using the glass jar, to employ a glass tank provided with electrodes and study the conductivity behavior at the instant the color appears, and follow the conductivity behavior as the phenolphthalein deepens in color. For this purpose a piece of apparatus was made as illustrated in Fig. 8. With such a piece of apparatus we should not only obtain the color reaction upon an indicator, but an increasing conductivity of the solution. The experiment is best and most forcibly shown by first filling the tank with pure distilled water to the top, having washed it out many times previously with distilled water to get it perfectly clean, when there will be practically no indication upon the galvanometer. The water is next poured out, and the tank carefully drained and dried as much as possible. It is then filled to the same level with a solution of phenolphthalein in ethyl alcohol to which some ammonium hydroxide solution has been added. This should be colorless, as will be the case if not too much ammonia was added. There will be practically no indication upon the galvanometer. We have then separately tested the conductivity of the water and the solution. Let us now see what the addition of water accomplishes. For this phase of the experiment the phenolphthalein solution is poured out, all but a small quantity. The writer usually leaves solution in the bottom to a depth of about five centimeters. Water is now very slowly added, when the red color begins to appear, and at the same instant the galvanometer begins to show conductivity. As the red color increases, the electrical conductivity increases, as is plainly shown by the galvanometer. The dilution is continued until the tank is full. The tank is constructed with a distance between the glass sides of only one centimeter, and therefore requires but a small volume of solution. The joint between the glass and the wood is made in a deep groove by putty. We will now close the present chapter with definitions of the new terms introduced.

Gramme-molecule.—Molecular weight of a compound expressed in grammes. The molecular weight of sodium chloride is 58.5. In order to use a gramme-molecule of sodium chloride, we would weigh out 58.5 grammes of the substance, for example.

Latent heat.—The amount of heat required to change the physical state of a body without changing its temperature. The heat given out or absorbed when certain bodies change their physical states.

Specific heat.—The amount of heat required to raise a gramme of a substance one degree in temperature as compared with the amount of heat required to raise one gramme of water one degree.

Calorie.—The unit of heat. The amount of heat required to raise one gramme of water one degree in temperature. There are large calories also, being ten times the small calorie, for convenience.

Heat exchange of calorimeter.—Error due to loss of heat by the calorimeter itself, by radiation, etc. To be determined by experiment with individual calorimeters by blank tests.

Elevation of boiling point.—Often expressed in works on physical chemistry as "the lowering of the vapor-tension of the solvent."

"Bumping."—The liberation of steam with almost explosive violence, from the smooth interiors of glass flasks when liquids are boiled in them. Prevented by introducing sharp points, as by the introduction of broken glass.

Dissociant.—A solvent that not only dissolves electrolytes, but breaks them down into ions at the same time. Benzine dissolves many electrolytes, but does not dissociate them, and therefore such a solution would be a non-conductor of the electric current.

Chemical affinity.—The attraction between the atoms in a molecule, whether due to electrical attraction or other forces.

Specific inductive capacity.—Dielectric constant. We owe to Cavendish (1771-81) the discovery of the fact that the amount of inductive effect which takes place through a dielectric is different for different substances. Consult physics.

Molecular conductivity.—Molecular conductivity of an electrolyte is equal to the specific conductivity of one cubic centimeter of the solution times the number of cubic centimeters containing a gramme-molecular weight. $M = N S$, where M is the molecular conductivity, N the number of cubic centimeters of the solvent containing the gramme-molecular weight of the electrolyte, and S the specific resistance of a cubic centimeter of the solution.

(To be continued.)

LIGNITE FOR LOCOMOTIVE FUEL.

LIGNITE has an important industrial value as fuel as it most frequently occurs in sections rather distant from the heavier and more ancient coal deposits. For this reason, holds the Railway Age, notwithstanding its inferior heat value, the railroads in Colorado, Wyoming and in the Southwest have made repeated attempts to use lignite for locomotive fuel, but with indifferent success and only to a limited extent. In Italy and Austria lignite is dried and compressed into blocks and used for making gas and for steam purposes. Some of the railways of Italy use it on locomotives without thoroughly drying, and that containing 15 per cent water has a heat value only about one half that of good coal. When freshly mined, lignite contains a large per cent of water, sometimes as much as 40 per cent, but this is reduced to 20 per cent by ordinary exposure to dry air. The best Colorado lignite when air dried contains fixed carbon 45 per cent, volatile matter 33 per cent, water 15 per cent, ash 7 per cent, while an ordinary grade has the following composition: Fixed carbon 40 per cent, volatile matter 32 per cent, water 20 per cent, ash 8 per cent.

Continuing in the same vein, the Railway Age remarks that repeated attempts have been made to improve lignite and make it better adapted for locomotive fuel by briquetting, but the expense attending this process has usually been found prohibitive. In this process the raw coal is ground fine and heated and mixed with a binder, and in this treatment most of the moisture is driven off. A sample carload of Wyoming lignite had a composition about the same as that of the ordinary grade of Colorado, as given above, and when made into briquettes it contains only about 1 per cent of moisture, 32 per cent volatile matter, 57 per cent fixed carbon and 10 per cent ash. The cost of the machinery in a plant for making 10 tons briquettes per hour is $40,000, and the interest charge on a plant for the production of 50,000 tons per year is 30 cents per ton. The royalty charge of patentee is 20 cents per ton, and the other items in the cost of manufacture make up a total sum of $1.60 per ton. The conclusion reached by the railroad which made the experiment in briquetting was, that with the coal costing $1.10 for mine run in the lignite country it would not be profitable to use briquettes for locomotive fuel.

Various arrangements of draft appliances have been used for burning lignite in its raw state. It is so light that it is easily drawn through the tubes, and to prevent sparks the netting must be fine and have a larger area than can be arranged in the smokebox, so that some form of enlarged diamond stack with cone and netting in it is usually employed. The air openings in the grate must be fine and the ashpan virtually closed. To produce draft under such conditions it is necessary to use a small exhaust nozzle and the back pressure on the piston is unusually high. The power of the locomotive is thus limited by the inability to force the fire, the back pressure in the cylinders, and the low heat value of the fuel. A very large grate, similar to that used for fine anthracite coal, is evidently the most suitable one for burning lignite, and the Wooten boiler with such a grate has been used in the West for this purpose.

The device which has proved most encouraging for burning lignite in locomotive boilers is the spirally corrugated tube. The extended experiments which have been made with this tube on eastern roads with good bituminous coal have shown conclusively that it is an efficient spark arrester. The edges of the corrugation are not worn after more than a year's service, showing that the sparks follow the spiral path and do not pass directly through the tube in a straight line. In this way they have time to cool off, their velocity is arrested and the engine does not throw out live sparks to the extent found with cylindrical tubes. A locomotive in the lignite region has been fitted with spiral tubes, and it has been found possible to enlarge the exhaust nozzle ⅝ inch in diameter and use an open straight stack. The engine is now able to haul one more car at higher speed in passenger service, with freedom from the danger of live sparks. The experiment is regarded as so successful that more engines are to be fitted with the spiral tube for use in burning lignite. It is quite possible that a more extended use of lignite will result in some improved methods of drying it and otherwise preparing it for locomotive use, and in this way an important economy in the use of locomotive fuel will be effected.

PHOTOGRAPHIC RECORDS OF N-RAYS.—R. Blondlot describes minutely an improved method of recording N rays by photography which should enable everyone to satisfy himself of their objective existence. N-rays from a Nernst filament are concentrated upon an electric spark gap by means of an aluminium lens, focusing being done by watching the brightness of a piece of ground glass illuminated by the spark. The spark terminals, which are of platinum, should have a regular convexity, and should be exactly opposite each other. To get a sensitive spark, the terminals are placed in contact, and then slowly drawn apart until the spark begins to diminish in brightness. At this maximum of brightness the spark also possesses its maximum of sensitiveness. The sensitive plate is placed behind the ground glass, and the latter is covered with black paper in which is cut a hole some 18 millimeters in diameter. With the same exposure two different impressions are taken, one with the N-rays and one without. When the plate is developed the N-ray exposure comes out first, and if a slow developer is used, it is possible to so arrange the development that only one impression shows in the final result. A good expedient for eliminating heat effects is to make exposures with the N-rays screened off with moist cardboard, and then repeating the exposure with cardboard soaked in a saline solution, which transmits the rays. The author says he has performed these experiments a great many times without a single failure, and in presence of a number of physicists who visited his laboratory to test his results.—R. Blondlot, Comptes Rendus, June 27, 1904.

TRADE NOTES AND RECIPES.

Priming of Gypsum Walls for Size Paint.—Pure gypsum walls are seldom found, the plastering consisting mostly of a larger portion of lime than gypsum. The writer recommends the following simple method to prepare them for size paint. Paint the walls once with pure undiluted sublac. If any places still remain dull, they should be coated again with diluted sublac. The main point is to obtain a uniform gloss. After two to three hours one can already go over the surface with a well-sifted size color. The price of sublac is about one dollar a gallon. The following method also suffices in most cases: 3 parts gloss oil and 2 parts turpentine or benzine are mixed well and applied quickly. Gloss oil costs 30 cents per gallon, and dries in one hour. If the walls should absorb to such an extent as to make a coating of the above-mentioned compounds disappear entirely, the walls should be primed previously with strong glue water.—Deutsche Maler Zeitung.

Practical Hints for Engraving and Sawing.—The chief factor in sawing is a good scroll saw; for fine work the smallest saws, No. 000, are the best. The leaf or blade of the saw ought to be rectangular, and where practicable have a square cross section. Flat saws do not turn so easily, and are as a consequence not so well adapted for the work. The inner edge of the tracing—that is, the cut of the graver—should not be touched by the saw. The saw should only eat away the gutter or the outside edge of it. It has been found much more advantageous to saw upon the side turned toward the operator rather than upon the opposite side. For example, when it comes to cutting out a gold monogram, the greater part of the sheet carrying the tracing will be used as a support. In regard to engraving, be it said that the smoother the surface upon which the work is to be done, the better. It is well to rub it down just before with a bit of finest emery cloth. The design must of course be drawn in first. Where possible it is always best to make this first on paper. Make a negative of it by pouncing, and retransfer this as a positive to the polished surface. If the metal be covered with a thin film of gamboge, the lead pencil drawing may be easily taken off the paper. Lay the paper with the pencil sketch face down upon the moist gamboge-covered surface, and by rubbing the back of the paper with any smooth, flat tool, the design will be quickly and effectively transferred. With a fine though not too sharp tracing tool—a pointed round needle file, knitting needle, or the like—go over the pencil sketch and sink it into the metal. Since gamboge gum is soluble in alcohol, it may now be removed from the plate by washing it in alcohol, and the sawing may now begin.

Whatever it is possible to hold in the hand, avoid by all means putting in the vise or pliers, because in this manner you gain much in the easier manipulation of the piece. The cut of the saw should be perpendicular to the surface sawed unless, of course, there are special reasons for having it otherwise. After the sawing is completed, a clever use of the graver may be needed. Thus, for instance, wherever a little of the metal extends beyond the tracing, this can be deftly removed by the oblique cutting edge of the graver.—Journal des Goldschmiedekunst.

Successful Process for Making Gold and Silver Ware Appear Antique.—Patience and experience are required to endow newly-manufactured gold and silver wares with the appearance of being old. Such a procedure becomes necessary, however, whenever it is intended that new wares shall pass for genuine antiques or when, new parts having been added to real old specimens to complete them, the whole shall present the same aspect.

With silver this is comparatively an easy task, but with gold it is far from so simple a matter, and a certain amount of practice is required. It is well to put into practice just those accidents which one strives to avoid when making new things. Gold wares should be intentionally scratched and marred if they are to counterfeit the abrasions and disfigurements obtained during the years of actual service; for this purpose they are often shaken up in a flask or wooden box with nails, sharp sand, and bits of flint or quartz. They are treated also to a bath of dilute ammonium sulphate, the ensuing brown spots are rubbed up with spirits of ammonia and powdered pumice stone, while the higher parts are again highly polished with a bit of rough leather (buffing stick). A little printer's ink thinned with oil of turpentine and applied with a soft brush to the cracks and crevices will add much to the ancient appearance. After this, clean up the whole, taking care not to remove all the black from the depressions. Silver ware that is to be gilded, is to be made to assume, in a word, the character of fire gilt, should be carefully scratched or marred before treating to the galvanic bath. Grasp them in the hand, which has been previously soiled with wax dissolved in turpentine, so that the most elevated projections shall [illegible] in spots coats of wax and be thus prevented [illegible] apply a heavy plating of the gold, and immerse the object for some minutes in a dilute solution of nitric acid. The lightly-gilded spots will be attacked, and the silver eaten slightly away. The whole piece may now be treated as is indicated above for gold ware. It is advisable to have before the operator a specimen of genuine old ware for constant comparison throughout the different stages. During the process of converting recently made articles into ostensible antiques, particular attention must be devoted to all screws, nuts, hinges, joints, and joint pins. Above all things else, sharp edges and any visible strokes of the file are to be avoided, for they would remain only to unmask the whole deception.—Neueste Erfindungen und Erfahrungen.

ELECTRICAL NOTES.

It has been discovered that magnetite, the black oxide of iron, is suitable for use as an electrode in an arc lamp. The arc flame issues from the negative terminal, and, striking the positive, produces heat. If the positive electrode cannot carry the heat away with sufficient rapidity it becomes hot and gives off light. In the magnetite lamp the positive electrode is a copper segment, which is of such size that it does not get too hot, and therefore does not wear away, forming a permanent part of the lamp. On the other hand, it does get sufficiently hot to avoid the deposition on it of material which may be shot out from the negative electrode, consisting in this case of fused drops of magnetite.

A water-cooled iron wire rheostat has been used at the Nancy Central Station, Paris, for testing a 1,000-kilowatt, 500-volt generator, says the Iron Age. Spirals of iron wire three millimeters in diameter were immersed horizontally in a tank, each spiral containing about 200 feet of wire. Six spirals took 1,660 amperes at 500 volts, the current per wire being thus 277 amperes. The test lasted five hours without any evidence of deterioration. Another spiral was then added, and the full 2,000 amperes easily carried. Two pumps supplied 2 liters of water per second, entering at 17 deg. C. and leaving at 77 deg. C. As 200 calories per second were supplied by the current, and only 120 taken away by the escaping water, it is calculated that the evaporation of water was at the rate of 0.143 liter per second.

Some figures recently published by the Berlin General Electric Company show that a trackless overhead trolley car, capable of holding 22 passengers, uses about the same amount of electric current as an ordinary street car with accommodation for 28 passengers, representing a higher cost of some 25 per cent. The maintenance of the trackless cars, owing to the greater wearing out of the rolling stock and the extensive need of lubricators, etc., is larger than on track cars, though in the latter case provision has to be made for repairs to permanent way. The total operating costs worked out at about 4d. per mile. Figures are also given for the operation of the trackless line in the Bila Valley. According to the latest reports, after three months' operation the cost of electric current was double that of a track road. This greater utilization of current, however, is calculated to represent only one-tenth of the sum which track roads require for interest and maintenance. A large part of the income of these trackless roads is obtained by carrying goods. It has been found that the streets are not at all injured by the trackless cars.

The announcement that the management of the Long Island Railroad, says the N. Y. Times, has placed an order in Pittsburg for the motors needed for the immediate equipment of its line in substitution for locomotives is of unusual interest. Power will be taken from a copper wire overhead, after the manner employed in trolley car operation. The motors are of the type ordered for use in the tunnel between Jersey City and Long Island. By the beginning of next summer it is intended to handle the entire passenger service of the road by electricity, so reducing the discomforts of travel in warm weather that the business of the road should be largely increased. Changes of this kind in the equipment of well-established steam railroads are extremely significant. They point in the direction which enterprising railway management must follow, or lose its suburban business to the competition of electric roads. The locomotive has rendered an invaluable service to civilization, but it is nearing the end of its usefulness, and every year finds its sphere of effective operation restricted. At best it is a monster with a voracious appetite and an extremely bad breath, intolerably noisy and very much of a nuisance generally.

To enlist rats in the construction of telephone systems may sound empirical to the electrical engineer, but we have it on the authority of Sound Waves that the familiar pest has been found a valuable assistant in this work. To stimulate, however, it is necessary to introduce his traditional enemy the ferret. Then the process is simple. The subterranean tubes for the reception of the cables having been laid, a rat is let loose at the starting point. Having run a little way, a trained ferret, with a string to his leg, is turned in after him. The tubes run into manholes at intervals, and the rat, furtively glancing back, sees the glaring eyes of his arch-foe rapidly approaching. By the end of the section of tube the rat is either overtaken or falls into the manhole, and then another rat is requisitioned to run the next block. At the end of each section the string is removed from the ferret's leg, and a small rope, which is then attached to the other end of the string, is hauled through. In turn a heavy cable, consisting of two or three hundred wires, is attached to the rope and likewise hauled through the tube. Presumably, it is necessary to see that the rat receives a liberal handicap, otherwise his opponent might catch him prematurely and dispatch him midway in the tube. This new ally is said to have been of much utility in the laying of the Des Moines-Omaha line.

SCIENCE NOTES.

The Deutsche Seewarte has added another to its many useful publications, "Tabellarische Reiseberichte," a collection of tabular reports of the meteorological logs received during the year 1903 from observers on ships. It has several times been suggested that observations made at sea should be published in a tabular form, similarly to those made at land stations; the late Admiral Makaroff was the last to urge the importance of doing so, but the question of expense has always stood in the way. The work in question does not attempt such a regular tabulation of observations, but gives a useful summary of some of the principal phenomena recorded on each voyage, e. g., the limits of the trade winds and monsoons, the force of wind, the storms experienced and the behavior of the barometer during their occurrence, noteworthy currents, sudden changes of sea temperature, etc. Each report also gives the length and nature of the voyage, so that any person interested in the meteorology of any particular part of the ocean can determine approximately the amount of materials available. It is proposed to issue a similar volume for each year.

Dr. H. Hergesell, president of the International Aeronautical Committee, has contributed to Beiträge zur Physik der freien Atmosphäre an interesting account of his kite observations on the Lake of Constance. The ascents were first made in the year 1900, and subsequently in the years 1902 and 1903, on both occasions with the assistance of Count Zeppelin, who lent his motor-boat for the purpose. It is understood that such observations are somewhat difficult at an inland station, as the wind velocity necessary for raising the kite (about 8 meters per second, or 18 miles per hour) is not always available without the artificial wind produced by the motion of a boat. Dr. Hergesell's experiments clearly show that, frequently, inversions of temperature and humidity occur at certain levels, which are not exhibited by observations made on mountain peaks, and the opinion is expressed both by Prof. Mascart (president of the International Meteorological Committee) and by himself that however useful in various ways, observations on mountain stations have not led to the results that were expected from them. He is of opinion that if any improvement is to be made in what he terms the present stagnant condition of meteorological science, it will be by the investigation of the upper strata of free air rather than by piling up observations made at ordinary meteorological stations—in other words by making meteorology a study of the physics of the atmosphere.

An interesting experiment is being carried out by the Scientific Sub-Committee of the Lancashire and Western Sea Fisheries of Great Britain. The object of these tests is to determine the extent and nature of the migrations of soles and plaice, and the degree of reduction of the fish population of the sea, on any area, which is produced by fishing. For the purpose of these experiments, about one thousand fishes, comprising mostly plaice and soles about eight inches in total length, are marked with a silver wire. The wire is threaded through the body of the fish. The wire on one side carries a bone button, and on the other a numbered brass label. These fish will then be released, and rewards are offered to fishermen who succeed in landing these marked fish, to return them to the authorities, setting forth data as to where caught, etc. It is anticipated that some 25 per cent of the marked fish will be recovered.

The Comptes Rendus, vol. cxxxvii., contains some valuable observations on the germination of seeds of orchids by Mons. N. Bernard, whose experiences warrant his making the interesting and rather remarkable statement that germination, at least in the case of some seeds of *Cattleya* and *Laelia* with which he experimented, is wholly dependent on the presence in the embryo of a filamentous endophytic fungus. In a fortnight after sowing the seeds some minute spherules, rendered evident by their green color, were produced. Some of the epidermal cells of these bodies elongated into short papillæ, but did not form any true hairs. It was observed that in aseptic sowings, even after the lapse of five months from the time when the green spherules made their appearance, no further development of the seeds had taken place. Many were destroyed by mold, sooner or later. If, however, the seeds in the state indicated were transferred to a tube in which was a culture of a certain hyphomycetous fungus, further growth almost immediately resulted, and it was found that the hyphæ of the fungus had penetrated the median part of the suspensor and the adjacent cells of the embryo. In fifteen days the seedlings had assumed their characteristic top-shaped appearance, developing a terminal bud and long absorbing hairs. In the cultures, besides the fungus which Mons. Bernard regards as necessary to germination, a coccobacillus was present, but it did not appear to have any effect, either in hindering or promoting germination; if, however, other fungi or bacteria were substituted for the particular kind of fungus found to be essential, the seeds, instead of germinating, were destroyed.

THE SORTIE OF THE RUSSIAN FLEET FROM PORT ARTHUR ON AUGUST 10, FROM THE DESCRIPTIONS OF OFFICERS OF THE BATTLESHIP "CZAREVITCH."*

Following the short account in the October number of this publication of the action of August 10, as observed from the "Askold," detailed accounts of the observations of the officers of the "Czarevitch" are now at hand. These accounts in part corroborate and in part differ widely from the earlier ones. As a matter of fact, even these statements frequently appear to be inaccurate and partisan, and by no means present a fair and unbiased view of the tactical events of the battle. However, until the Japanese version of the affair is at hand, they will form the only foundation upon which to build up the story of this, the only real naval battle of the war. Extracts from the "Askold" description are included in the following account.

I. THE ACTION.

On August 10 at six o'clock in the morning, the Russian fleet under command of Rear-Admiral Witthöft, and sailing under orders from a higher authority, left for Port Arthur to attempt to join the cruiser squadron at Vladivostok.

The fleet consisted of the following vessels: Battleships—"Czarevitch," "Retvisan," "Pobieda," "Peresviet" (Rear-Admiral Count Uchtomski), "Poltava," "Sevastopol." Armored cruisers—"Askold" (Rear-Admiral v. Reitzenstein), "Pallada," "Diana." Protected cruiser—"Novik." Eight torpedo boats.

The armored cruiser "Bayan" was obliged to remain in Port Arthur because of the injuries she had sustained through the explosion of a mine under her bottom.

Concerning the disposition of the Japanese fleet, it was only known that a few cruisers and torpedo boats did scout duty outside of the harbor. Nothing was known about the location of the main squadron.

The sortie of the Russian fleet began with the sending forth of the mine removal division. For this purpose steamers joined together in pairs by steel cables were used. The mines, caught in the bight of such a cable, which did not explode at the impact or from the consequent shaking up, were dragged from the channel. The mine-grappling vessels were followed by the fleet in line-ahead and in the above-mentioned order. The cruisers in this order, "Novik," "Askold," "Pallada," "Diana," and the torpedo boats, closed up with the battleships.

After the harbor had been cleared at 8 o'clock, the fleet steered in a southeast direction toward the Shantung Cape for about an hour, at a speed of 12 knots. Meanwhile the Japanese cruisers of the blockading fleet, closing in upon the enemy from port and starboard, came in touch with the Russians, while the torpedo boats running ahead dropped floating mines in the course. Because of this the Russians were obliged to proceed in a sinuous line, and their advance was consequently considerably retarded.

According to a description, four large and small cruisers were in touch with the Russians both to starboard, near the head of the Russian line, and to port astern, while at a greater distance several other small cruisers were in sight when the main Japanese fleet appeared to port ahead at 11 A. M.

It is said that Admiral Witthöft then changed his course somewhat to starboard, but soon afterward returned to the original direction, which was maintained from then on. (See Fig. 1.) For a short time a running fight at very long range (apparently not less than 8,000 meters) took place.

The accounts of the second phase of the battle which now followed are entirely contradictory and confused. While a number of officers of the "Czarevitch," as well as those of the "Askold," mention a repeated long-range and ineffectual action to port in which the fleets passed and repassed in line-ahead, others maintain that the main Japanese fleet swung across the head of the Russians in a large arc and that then the above-mentioned long-range fight took place to starboard. According to the statements of these officers, this part of the action would have been as represented in Fig. 2.

No conjectures need be made here as to which of these is the more probable view, as the action was practically without effect until 1 P. M.

After the fleets had passed each other, the Russians steadily pursued the southeast course, while the Japanese, turning to port and swinging into the same direction, remained far behind—apparently 10 to 12 knots (?). The Russians, believing themselves able to outfoot the Japanese, because the boilers and engines of the latter had been strained by long service on blockade, now proceeded at full speed in order to escape. However, as early as 3 P. M. the Japanese had again so far overhauled the Russians that they could renew the battle. As a matter of fact, the Japanese had only temporarily fallen back in order to allow a number of armored cruisers to reach the scene of action. These cruisers appeared between 2 and 3 o'clock, aft to port, and, with the Japanese battleships, began firing at excessively long range.

In the running fight that now developed, the Japanese steadily drew up on the Russians and concentrated their fire upon the leading vessel, which was repeatedly struck by shells of large caliber fired from the cruisers to port and the battleships to starboard, and at 3 P. M. had lost her commander and could no longer be steered.

At this point the heads of the two fleets were about on a line. At no time had the Japanese allowed the range to become less than six or seven thousand meters.

A 12-inch shell that struck the foremast had killed Admiral Witthöft, and a second, hitting the conning tower, either killed the members of the staff or rendered them unconscious. The rudder had jammed hard to port, so that the "Czarevitch" circled to the left and thus sheered out of line to the lee of the firing.

Hereupon the "Retvisan," the second in line, swung around without apparent reason and started toward the main Japanese fleet, which proceeded to meet the

* Translated from the Marine Rundschau, Berlin.

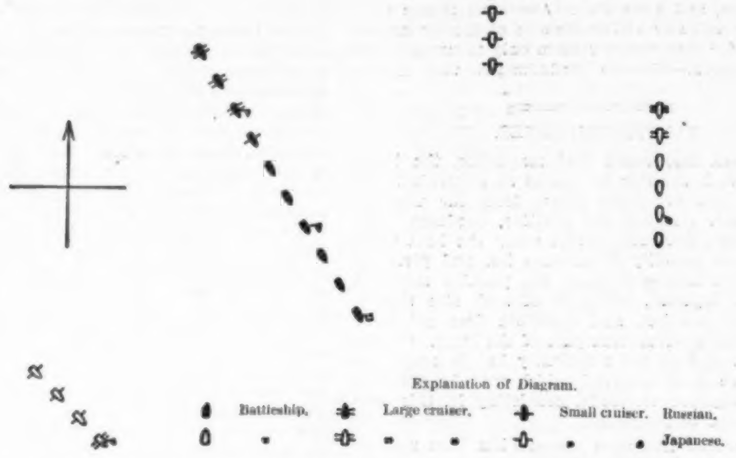


FIG. 1.—SHOWING RELATIVE POSITIONS OF RUSSIAN AND JAPANESE FLEETS AT THE OPENING OF THE ENGAGEMENT.

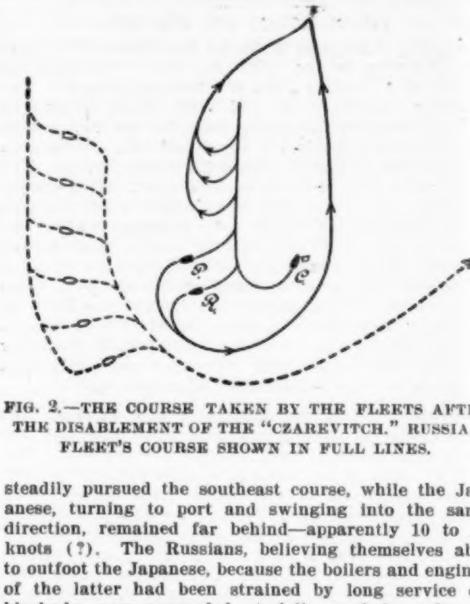


FIG. 2.—THE COURSE TAKEN BY THE FLEETS AFTER THE DISABLEMENT OF THE "CZAREVITCH." RUSSIAN FLEET'S COURSE SHOWN IN FULL LINES.

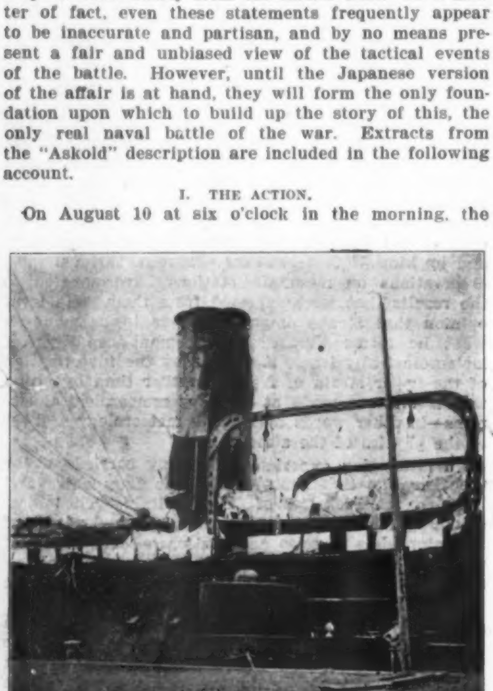


FIG. 5.—EFFECT OF SHOTS NOS. 7 AND 8 OF THE SKETCH.

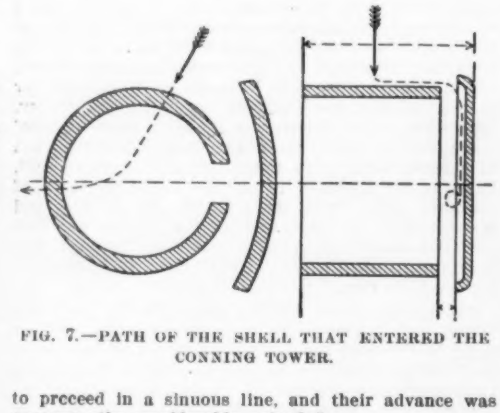


FIG. 7.—PATH OF THE SHELL THAT ENTERED THE CONNING TOWER.

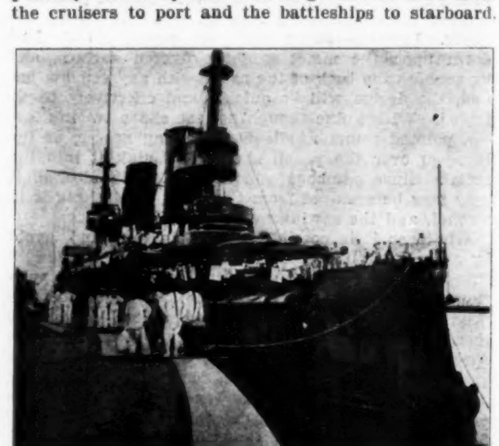


FIG. 6.—SHOWING THE HIT WHICH TORE AWAY THE STARBOARD ANCHOR.

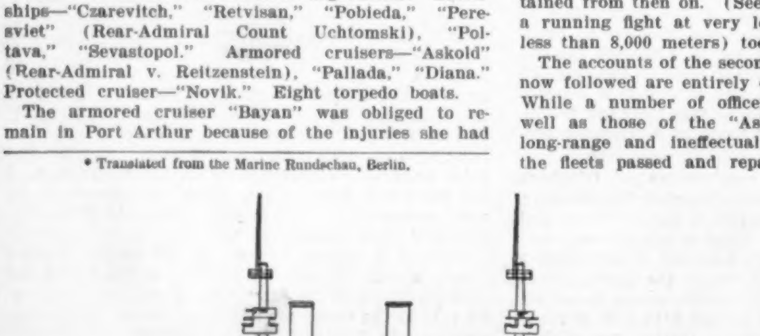


FIG. 3.—DIAGRAM SHOWING HITS ON PORT SIDE OF "CZAREVITCH."

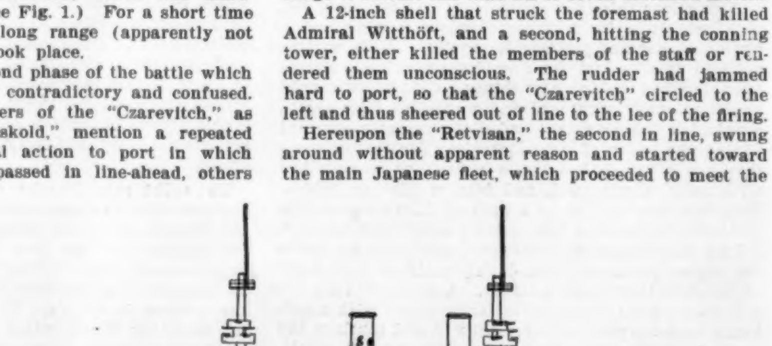


FIG. 4.—DIAGRAM SHOWING HITS ON STARBOARD SIDE OF "CZAREVITCH."

THE SORTIE OF THE RUSSIAN FLEET FROM PORT ARTHUR ON AUGUST 10.

seeming attempt at ramming by a corresponding turn of eight points to port.

The breaking from the line by the "Retvisan" was the signal for the general dissolution of the same. After she had approached the Japanese line by some 1,500 meters, she again swung to port, and circling around the "Czarevitch," laid her course for Port Arthur. The "Pobieda" followed her maneuver, while the three rearmost battleships, turning to starboard, had already taken the same direction.

The Japanese main fleet had meanwhile ceased firing, remained for a time motionless, and then proceeded in a northeast direction without attempting to further molest the Russians flying toward Port Arthur.

The Russian cruisers and torpedo boats which had gathered together to the leeward of the Japanese fire during the action of the afternoon, were detached before the main Russian line broke, with the command to try to reach Vladivostok independently. With what success this command was executed has already been partly told in the October number.

And so, at the fall of darkness, the "Czarevitch" alone remained at the scene of action, surrounded by Japanese torpedo boats. The original intention also to return to Port Arthur was given up, as the injuries received did not warrant even the chance of a second meeting with the main fleet of the enemy. It was determined to proceed toward the southeast and eventually force a passage single-handed to Vladivostok.

The repeated attempts by the Japanese to torpedo her during the night were successfully nullified by steaming at full speed. In consequence of the injured funnels, enormous quantities of coal were thereby consumed, the total amount used during the day being some 470 instead of 80 tons.

After the action the difficulties of navigation were greatly increased. The conning-tower compass and the charts had been shot to pieces. The remaining compasses are supposed to have become unreliable in consequence of the concussion incident to the explosions, and the vessel had to be steered by the stars. By mere chance, daylight discovered the ship near the northeast Shantung Cape.

A determination of the injuries showed that in the estimation of the acting commander, Capt. Schoumoff,

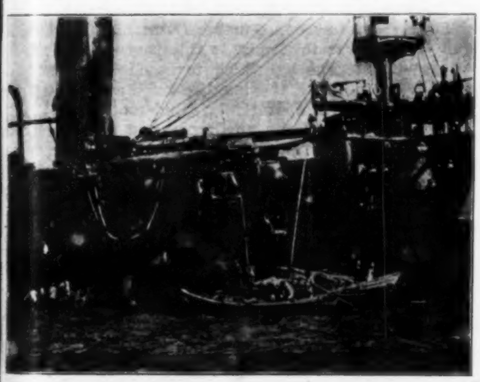


FIG. 11.—SHOWING HITS UNDER THE AFTER FUNNEL AND THE AFTER BRIDGE. SHOTS NOS. 9 AND 10 OF THE SKETCH.

the ship was not sufficiently seaworthy to steam to Vladivostok. It was therefore decided to go to the nearby neutral port of Tsingtan, and this harbor was reached at 11 o'clock the same night. Among the serious injuries which were the cause of this determination, are mentioned:

1. The striking of the foot of the foremast by a 12-inch shell, which killed Admiral Witthöft, and whereby the support of the mast was so far shot away that the latter threatened to fall.

2. The injuries to the funnels whereby the coal consumption was increased so much that the fuel would have been insufficient to carry the vessel to Vladivostok.

3. A 12-inch shell hit on the starboard side under the forward 6-inch turret, below the waterline, which caused a small leak in the compartment in question.

II. DETAILS OF THE ENGAGEMENT.

After the "Czarevitch" was put out of action, it is claimed that the "Peresviet" was signaled to take the lead, but made no answer to this order. It is further stated that at about the same time the "Retvisan" signaled "Do not follow," and sheered off to starboard

FIG. 10.—WRECK OF THE FORWARD FUNNEL, SHOT NO. 6 OF THE SKETCH.

toward the Japanese. Russian officers are of different opinions concerning the reasons for this maneuver of the "Retvisan," which was bound to cause confusion in the ill-trained Russian line. Some maintain that the "Retvisan" intended to attempt to ram, but in this case the signal would have been superfluous and without reason. Others are of the opinion that the

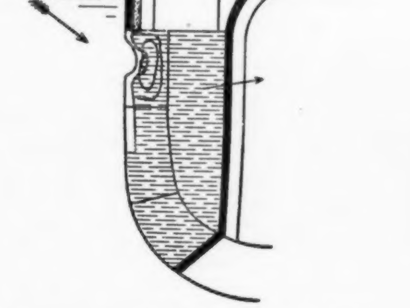


FIG. 13.—THE HIT BELOW THE ARMOR BELT.

"Retvisan" wanted to cover the badly mauled "Czarevitch." If this were the case, the commander of the "Retvisan" would find it still more difficult to justify his actions.

III. INJURIES OF THE "CZAREVITCH." (See Sketches and Photographs.)

According to the reports of the Russian officers, the ship was struck by fifteen 12-inch and a greater number of shells of smaller caliber.

Shot No. 1: A 12-inch shell forward on the starboard side at the level of the upper deck, striking the hogs back of the bow anchor. The projectile tore a hole in the ship's side 2 x 2 meters, passed through the bow and sheet anchor chains, but hardly left a trace of its passage in the hold. Both anchors were lost.

Shot No. 2: 12-inch shell on the starboard side, level with the upper deck, and just under the forward 12-inch turret. The shell tore a hole in the ship's side 1 x 1 meter, but did practically no damage in the interior.

Shot No. 3: 12-inch shell that struck the armor of the forward 12-inch turret. Ineffective.

Shot No. 4: 12-inch shell squarely striking the starboard side of the forward conning tower. The path of the shell is shown in Fig. 7. Of the persons in the conning tower, the ship's navigator, a sub-lieutenant, the helmsman, and two or three orderlies were killed, their heads being blown off, while two officers were stunned. Through the falling bodies, the wheel was turned hard to port, the steering gear being uninjured. The compass was destroyed. The cables running along under the roof of the conning tower were torn away and the mechanical connection with the engines destroyed. The head of the shell passed out of the tower in the direction of the arrow and buried itself in the hammock boxes that form the forward bridge rail, and here it was later found.

Shot No. 5: A 12-inch shell that squarely struck the foot of the foremast between the upper and lower bridges. The projectile pierced the starboard side of the mast and burst against the port side. Toward the bow the iron plates of the mast are entirely torn away. At the back only does a connection between the two bridges remain, but this is not strong enough to bear the weight of the heavy fighting mast. The latter actually rests on the upper bridge only, being joined to this by strong angle irons that were uninjured. The searchlight cables in the mast were broken. The shot killed Admiral Witthöft, the fleet navigator and some fifteen men. The chief of staff, Admiral Matusewitch, and the commander, Capt. Ivanoff, were wounded. The officers were probably in the fire lee of the tower.

Shot No. 6: A 12-inch shell squarely struck the lower part of the forward funnel. The shell pierced the starboard side and exploded against the port side which was torn to pieces.

Shots Nos. 7 and 8: Two 12-inch explosive shells injured the upper and lower parts of the rear funnel. They struck and exploded against the starboard side of the smokestack which was ripped up and torn from top to bottom. The port side shows no injury that can be traced to either of these shots.

Shot No. 9: Probably an 8-inch projectile fired from a cruiser. The shell pierced the port side wall of the superstructure below the launch. Several injuries re-

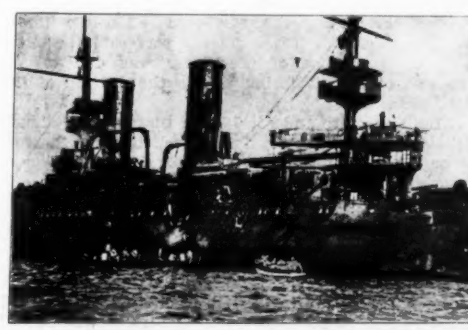


FIG. 12.—SHOWING THE THREE MOST IMPORTANT HITS UPON PORT SIDE OF THE "CZAREVITCH."

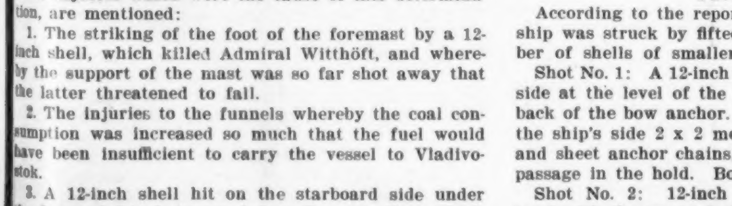
1. Under the after funnel, shot No. 9 of the sketch. 2. Under the after conning tower, shot No. 10 of the sketch. 3. At the after turret, shot No. 15 of the sketch. This shot entirely tore away a bollard.

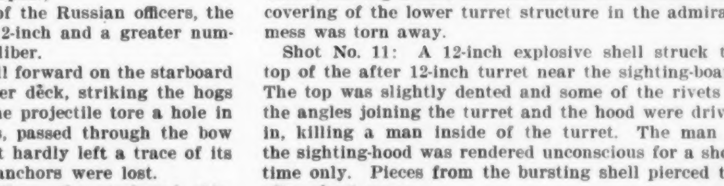
sulted, among them the destruction of the bakery. The shell made a round hole about 1 meter in diameter.

Shot No. 10: Another 8-inch shell that pierced the port side of the forward lower edge of the rear 6-inch turret, leaving a hole 1 x 0.55 meter in the wall. The covering of the lower turret structure in the admiral's mess was torn away.

Shot No. 11: A 12-inch explosive shell struck the top of the after 12-inch turret near the sighting-board. The top was slightly dented and some of the rivets of the angles joining the turret and the hood were driven in, killing a man inside of the turret. The man in the sighting-hood was rendered unconscious for a short time only. Pieces from the bursting shell pierced the after chart room.

Shot No. 12: 12-inch explosive shell destroyed th forward chart room, abaft the foremast.





Below the forward
er funnel, shots

Shot No. 13: 12-inch explosive shell struck the after 12-inch turret on the port side. The shell probably burst at impact and did no damage.

Shot No. 14: Probably a 12-inch shell that struck some 2¼ meters below the waterline, under the forward 6-inch turret, and under the armor belt. According to the reports of divers the projectile struck the joint of two of the outer skin plates. The plates, frames and supports are said to be dented and bent, but not torn, for a longitudinal distance of about 3½ meters. The covering-strap is supposed to have jarred off (see Fig. 13) and about 150 tons of water allowed to enter the compartment behind the downward curved armor deck, through the rivet holes. The "Czarevitch" entered the harbor with a barely perceptible list to starboard.

Shot No. 15: A 12-inch explosive shell passed through the port after-deck railing and the upper deck. The bollard is half torn away. The teakwood covering of the upper deck is ripped up for about 4 square meters. The wood did not burn and the deck planking splintered little.

The following facts may be noted in respect to these injuries:

1. As but part of the Japanese shells pierced the sidewall or did barely perceptible damage in the interior of the vessel, we may conclude that they exploded too soon. However, in this respect, the shots that struck the foremast and the funnel differ very widely from most of those that struck the hull. Much may be considered due to the difference in the effect of a shell and an explosive shell. It will probably not be far from the truth to finally conclude that the Japanese used some "half-armor shells with bottom ignition."

2. In spite of the wooden deck and of the fact that all boats were on board the splintering effect was small.

3. The wooden decks did not catch fire as was the case in the Chino-Japanese war.

4. In no place was the armor pierced; all the vital parts lying underneath the upper armored deck were absolutely uninjured. Some pieces of the burst shell fell through the after funnel upon the boilers under it and damaged a few superheater pipes. The explanation of the ineffectiveness of the heaviest Japanese shells against the Russian armor may be found in the tremendously long range and the apparent non-use of armor-piercing projectiles.

5. The hit below the starboard water-line under the forward 6-inch turret did not perforate the outer skin. The entrance of the water was due to the loosening of the rivets incident to the denting of the outer plates.

6. Both the fore and aft 12-inch turrets were struck without injury to the revolving mechanism of the turret or the ammunition-serving apparatus of the guns. However, according to the statement of a German officer who visited the "Czarevitch," the forward turret shows a large groove on the starboard side.

There is no reliable information at hand concerning the quantity of ammunition used by the Russians. According to one of the officers the lack of 12-inch shells—it appears 74 to 76 were fired from the forward turret and 40 to 45 from the rear turret—was one of the reasons for putting in to Tsingtan.*

LOSS AMONG THE CREW OF THE VESSEL.

According to the report of the ship's doctor four officers and eight men were killed and fifty officers and men were wounded. Nothing detailed concerning the nature of the wounds is known. Stress is laid by all upon the terrible and deadly effect of the explosive shell. As long as 24 hours after the action many complained about deafness, dizziness, loss of memory and headaches without directly being injured. The hair and beards, and partly also the skin, of those who were in the neighborhood of a bursting explosive shell were colored an intense yellow. A similar discoloration shows on the ship at the points of the explosions.

FINAL REMARKS.

When we regard the actions of the two naval forces in this last battle, considering the enormous value which the control of the sea means to both belligerents, and when we understand what both sides risked and what they could have gained, many of the proceedings of the Russians as well as of the Japanese seem puzzling to us.

Without doubt, since the beginning of the war the Russian fleet has had very little confidence in its capability and its ability to use the weapons intrusted to it. Not only was confidence and tactical knowledge missing because of the lack of squadron training, but the use of the weapons was not understood. Up to the present no Russian torpedo boat has fired a torpedo. As stated by Russian officers, the boats were exclusively used for laying mines, for scout duty and to fight the Japanese torpedo boats. The uniform lack of success in the last was due to the fact that the Russian torpedo boats were neither accompanied nor backed up by larger and more powerful ships without which the Japanese boats never advanced. The Russians never seem to have thought of using the boats at night. It can therefore be understood why the Russian cruisers and torpedo boats were considered a hindering addition that had to be protected during the sortie of August 10, instead of an offensive instrument which could have done good service in preparing for the sortie as well as during the following night.

But the Japanese also were unable to properly use their torpedo boats. All Russian officers remark that the Japanese torpedo tactics lack nothing in dash, but that the weapon itself is not on a level with its capability. The comparatively insignificant result of the first torpedo attack of February 8 and 9 upon the unconscious Russian fleet lying at anchor in double formation in Port Arthur, seems to confirm this statement. The opportunity in this case could not have been more favorable for the Japanese, and still out of 23 torpedoes fired only 3, or 13 per cent, scored hits.

And so it is explainable that the "Czarevitch" was able to escape from the torpedo boats surrounding her, during the night from the 10th to the 11th of August, although the opportunities for attacking the thoroughly battered vessel were excellent.

Judging from the information at hand we can understand the tactics of both participants in the action of August 10, with the exception of the last phase of all. By means of an exceptionally well organized scout service the Japanese cruisers were able to put their main fleet in touch with the Russians, within 3 hours of the latter's sortie. This maneuver was simplified because geographical necessities to a certain extent prescribed the Russian course. The great superiority of the Japanese in gunnery and in artillery appliances induced them to give battle at extremely long range with the intention—which has been the Japanese policy throughout the entire naval proceedings of the war—to injure the enemy as much as possible with the least danger to themselves in order to remain strong enough to encounter the threatening Baltic fleet. If we consider this point we can understand why the Japanese were satisfied with driving back the Russian fleet to Port Arthur, and why they did not attempt their annihilation. This tactical proceeding of the Japanese was only made possible by the superiority in speed which enabled them to choose their own distance without being placed at a disadvantage in other matters.

Incomprehensible, on the other hand, is the course of the main Japanese fleet as soon as the enemy began to retreat to Port Arthur. But until the Japanese version of the action is obtainable it would be a waste of time to attempt to explain this point.

As far as our information is correct the tactics of the Russians are understandable up to the point where they evidently became convinced that their inferiority in speed made escape impossible. From that moment they were morally released from the order to cut their way through to Vladivostok and from then on they should have endeavored to injure the enemy by means of which they were capable—that is, at short range. The time for this was given by the "Retvisan" when she turned to starboard; but the intention was misunderstood or at any rate not followed by any other Russian vessel.

The marksmanship of the Japanese is regarded with undisguised wonder by the Russian officers. The range at which the Japanese had to score their hits is, according to Russian estimates, between 7,000 and 8,000 meters. We must not lose sight of the fact, however, that these are only estimates, for, as the Russian officers admit, the range-finders in use were not available for such distances. All the same, the marksmanship of the Japanese was excellent and far superior to that of the enemy, inasmuch as the Japanese possessed telescope-sights which the Russians did not.

In criticising the Russian gunnery we must not forget that the fleet, bottled up in Port Arthur, had very little opportunity for practice. Thus, the "Czarevitch" used her heavy guns for the first time during the war, in the action of August 10.

From the standpoint of the naval officer as well as that of the constructor, the course of the war has been followed with vast interest, and many hoped to see the theories of the present naval architects thoroughly tested. Even if the results up to the present have been meager, many points may still be raised, and the action of August 10 has given us many valuable indications of where improvements in the details of our naval construction may be made.

But what has been the influence of this war on the type of our vessels? The question does not seem unfair inasmuch as the battleship has been little in evidence as an active factor, while the visible successes of the war thus far have undoubtedly remained with the torpedo boat, the cruiser, and the mine. We can easily understand that many who are unaccustomed to go deeply into marine questions have been deluded by the deeds of the Japanese torpedo boats on February 8 and 9, by the successes of the Russian cruisers against unprotected Japanese torpedo boats, and by the losses on both sides due to mines. And the younger school of France has not missed this opportunity to smooth the rough path of its champion, Minister of Marine Pelletan, in the coming budget meeting. The writer of a memoir entitled "The Bankruptcy of the Armored Vessel," climaxes his observations of this war with the sentence: "The mastery of the sea belongs to the unarmored fleet of such speed that no armored vessel can overtake it and no armored vessel escape it."

We may ask, in answer: What would such a fleet have to be able to do toward holding the Russian battleships in Port Arthur if the two opponents had been equally proficient in gunnery? What would have become of the Japanese transports if the Russian fleet merely threatened by an unarmored squadron of this kind, had attained the high seas? And, on the other hand, would the Russian Vladivostok squadron have dared to leave its harbor to attack the lines of communication of the enemy if a superior and more powerful Japanese fleet had been in a position to cut off the retreat to this harbor?

Finally, what would have been the success of the Japanese torpedo attack on the Russian squadron on February 8 and 9, and the frequent mine operations in the roadstead of Port Arthur, if, on the one hand, the scout and guard duty had been more efficiently executed and more strongly backed up, and on the other side, the powerful offensive and defensive vessels had not reinforced the attacks?

Nothing, in our estimation, can better prove the necessity for having a battleship backbone for a fleet, than the past occurrences of the war, and England has acted upon this belief with the foresight peculiar to her in naval matters. She has greatly increased the offensive and defensive characteristics of the battleships of the "Lord Nelson" class as compared to those of the "King Edward" class, and has sought to decrease the building of armored cruisers. After all has been said, the mastery of the sea, in spite of mines, torpedoes, and submarines, lies with the powerful and sufficiently speedy battleship. And so it will remain so long as the gun can hold its own as a long-range weapon with the torpedo, for "no one can get around the fact that where he wishes to rule, there he must strike."

* It was afterward learned that 580 to 600 shots were fired from the 6-inch guns.

[Concluded from SUPPLEMENT No. 1512, page 24227.]

NORTH POLAR EXPLORATION: FIELD WORK OF THE PEARY ARCTIC CLUB, 1898-1902.*

By Commander R. E. PEARY, United States Navy.

IN this journey I had determined conclusively the northern limit of the Greenland Archipelago or land group, and had practically connected the coast southward to Independence Bay, leaving only that comparatively short portion of the periphery of Greenland lying between Independence Bay and Cape Bismarck indeterminate. The non-existence of land for a very considerable distance to the northward and northeastward was also settled, with every indication pointing to the belief that the coast along which we traveled formed the shore of an uninterrupted central polar sea, extending to the Pole, and beyond to the Spitzbergen and Franz Joseph Land groups of the opposite hemisphere.

The origin of the floe bergs and palæocrystic ice was definitely determined. Further than this, the result of the journey was to eliminate this route as a desirable or practicable one by which to reach the Pole. The broken character of the ice, the large amount of open water, and the comparatively rapid motion of the ice, as it swung round the northern coast into the southerly setting East Greenland current, were very unfavorable features.

During my absence some thirty-three musk oxen and ten seals had been secured in the vicinity of Conger; caches for my return had been established at Thank God Harbor, Cape Lieber, and Lincoln Bay, and sugar, milk, and tea had been brought up from the various caches between Conger and Cape Louis Napoleon.

July was passed by a portion of the party in the region from Discovery Harbor westward via Black Rock Vale and Lake Hazen, where some forty musk oxen were secured.

During August and early September various other hunting trips of shorter duration were made, resulting in the killing of some twenty musk oxen.

1900-1901.

The middle of September I started with Henson and four Eskimos to Lake Hazen to secure musk oxen for our winter supply, it being evident that my ship would not reach us. Going west as far as the valley of the Very River, by October 4, ninety-two musk oxen had been killed. Later nine more were secured, making a total of 101 for the autumn hunting.

From the beginning of November to March 6, the greater portion of the time was passed by my party in igloos built in the vicinity of the game killed in various localities from Discovery Harbor to Ruggles River.

April 5.—I left Conger with Henson, one Eskimo, two sledges, and twelve dogs for my northern trip. At the same time the remainder of the party, with two sledges and seven dogs and pups, started south for Capes D'Urville and Sabine to communicate with or obtain tidings of my ship. On reaching Lincoln Bay, it was evident to me that the condition of men and dogs was such as to negative the possibility of reaching the Pole, and I reluctantly turned back.

Arriving at Conger, after an absence of eight days, I found the remainder of my party there. They had returned to Conger after an absence of four days, having proceeded one-third of the distance across La[illegible] Franklin Bay.

Fortunately, the night before I arrived, one of the Eskimos secured several musk oxen above St. Patrick's Bay, which enabled me to feed my dogs before starting south, which I did with the entire party on April 17.

April 30.—At Hayes Point I met the party [illegible] "Windward" attempting to reach Conger, an[illegible] my mail, learning that the "Windward" was [illegible] Harbor with Mrs. Peary and our little girl [illegible] After a rest at the D'Urville box house, I w[illegible] the "Windward," arriving May 6.

After a few days' rest the work of establish[illegible]

* From manuscript, as read before the Peary Arctic Club, [illegible] of the National Geographic Society, and reprinted in Smith[illegible] tution Report.

caches along the coast northward toward Conger was commenced and continued until the middle of June.

Then the preparing of Payer Harbor for winter quarters was carried on till July 3, when the "Windward" broke out of the ice and steamed over to the Greenland side.

July was devoted to killing walrus, and 128 were secured and transported to Payer Harbor.

August 4.—The "Erik," sent up by the club in command of Secretary H. L. Bridgman to communicate with me, arrived at Etah.

The usual tour of visits to the Eskimo settlements was then made, and both ships pressed into the work of hunting walrus until August 24, when the "Windward" proceeded southward, and the "Erik" steamed away to land me and my party and the catch of walrus at Payer Harbor.

A large quantity of heavy ice blocking the way to Payer Harbor, I requested Secretary Bridgman to land me and my party and walrus meat in a small bight, some twelve or fifteen miles south of Cape Sabine, from whence I could proceed to Payer Harbor in my boats or sledges when opportunity offered. This was done, and on the 29th of August the "Erik" steamed away.

1901-2.

On the 16th of September I succeeded in reaching Payer Harbor, crossing Rosse Bay partly by sledge and partly by boat, and going overland across Bedford Pim Island.

Soon after this my Eskimos began to sicken, and by November 19, six of them were dead.

During this time I personally sledged much of the material from Erik Harbor to headquarters, and Henson went to the head of Buchanan Bay with some of the Eskimos and secured ten musk oxen.

The winter passed quietly and comfortably. Two more musk oxen were secured in Buchanan Bay, and six deer at Etah.

January 2.—Work was begun in earnest on preparations for the spring campaign, which opened on the 11th of February. On this day I sent off six sledges, with light loads, to select a road across the mouth of Buchanan Bay, and build an igloo abreast of Cape Albert. On the 12th I sent two of my best hunters on a flying reconnoissance and bear hunt in the direction of Cape Louis Napoleon.

On the 13th eight sledges went out, taking dog food nearly to Cape D'Urville. On the 16th my two scouts returned with a favorable report, and on the 18th ten sledges went out loaded with dog food to be taken to Cape Louis Napoleon. This party returned on the 22d.

On the evening of the 28th everything was in readiness for Henson to start the next day, it being my intention to send him on ahead with three picked men and light loads to pioneer the way to Conger, I to follow a few days later with the main party.

A northerly gale delayed his departure until the morning of March 3, when he got away with six sledges and some fifty dogs. Two of these sledges were to act as a supporting party as far as Cape Lawrence.

At 9 A. M. of March 6, fourteen sledges trailed out of Payer Harbor and rounded Cape Sabine for the northern journey, and at noon I followed them with my big sledge, the "Long Serpent," drawn by a team of ten fine grays. Two more sledges accompanied me. The temperature at the time was —20 deg. F. The minimum of the previous night had been —38 deg. F.

We joined the others at the igloos abreast of Cape Albert, and camped there for the night. Temperature —43 deg. F.

The next day we made Cape D'Urville in temperature from —45 deg. to —49 deg. F.

Here I stopped a day to dry our foot gear thoroughly, and left on the morning of the 9th with some supplies from the box house. Two sledges returned from here. Camped about five miles from Cape Louis Napoleon. The next march carried me to Cape Fraser and the next to Cape Collinson. During this march, for the first time in the four seasons that I have been over this route, I was able to take a nearly direct course across the mouth of Scoresby Bay, instead of making a long detour into it.

One march from Cape Collinson carried me to Cape Lawrence, on the north side of Rawlings Bay.

The crossing of this bay, though more direct than usual, was over extremely rough ice. Learning from Henson's letter at Cape Lawrence that I had gained a day on him, and not wanting to overtake him before reaching Conger, I remained here a day, repairing several sledges which had been damaged in the last march. Five men, with the worst sledges and poorest dogs, returned from here.

Three more marches took us to Cape von Buch, on the north side of Carl Ritter Bay, temperature ranging from —35 deg. to —45 deg. F. Heavy going in many places.

Two more marches carried us to the first coast valley north of Cape Defosse. I had now gained two days on the advance party. The character of the channel ice being such that we were able to avoid the terrible ice-foot which extends from here to Cape Lieber, and my dogs being still in good condition, I made a spurt from here and covered the distance to Conger in one march, arriving about an hour and a half after Henson and his party.

I had covered the distance from Payer Harbor to Conger, some 300 miles, in twelve marches.

Four days were spent at Conger overhauling sledges and harness, drying and repairing clothing, and scouting the country, as far as The Bellows, in search of musk oxen. None were seen, but about 100 hares were secured in the four days. Temperature during this time from —40 deg. to —57 deg. F. Seven Eskimos returned from here, taking with them the instruments of the Lady Franklin Bay Expedition and other items of government property abandoned here in 1883.

On the morning of the 24th I started north with nine sledges. We camped the first night at "Depot B." The next march I had counted on making Lincoln Bay, but just before reaching Wrangell Bay a sudden, furious gale, with blinding drift, drove us into camp at the south point of the bay. Here we were storm bound during the 26th, but got away on the morning of the 27th and pushed on to Cape Union, encountering along this portion of the coast the steep side slopes of hard snow, which are so trying to men and sledges and dogs.

Open water, the clouds over which we saw from Wrangell Bay Camp, was about 100 yards beyond our igloo, and extended from there, as I judged, northward beyond Cape Rawson, and reached entirely across the channel to the Greenland coast at Cape Brevoort, as in 1900.

Fortunately, with the exercise of utmost care, and at the expense of a few narrow escapes and incessant hard work, we were able to work our sledges along the narrow and villainous ice-foot to and around Black Cape.

The ice-foot along this section of the coast was the same as was found here by Egerton and Rawson in 1876 and Pavy in 1882, necessitating the hewing of an almost continuous road; but a party of willing, light-hearted Eskimos makes comparatively easy work of what would be a slow and heart-breaking job for two or three white men. Beyond Black Cape the ice-foot improved in character, and I pushed along to camp at the "Alert's" winter quarters. Simultaneously with seeing the "Alert's" cairn three musk oxen were seen a short distance inland, which I went away after and secured. The animals were very thin, and furnished but a scant meal for my dogs.

One march from here carried us to Cape Richardson, and the next under the lee of View Point, where we were stopped, and driven to build our igloo with all possible speed, by one of the common arctic gales. There were young ice, pools of water, and a nearly continuous water sky all along the shore.

As the last march had been through deep snow, I did not dare to attempt the English short cut across Fielden Peninsula behind Cape Joseph Henry, preferring to take the ice-foot route around it.

For a short distance this was the worst bit of ice-foot I have ever encountered. By the slipping of my sledge two men nearly lost their lives, saving themselves by a most fortuitous chance, with their feet already dangling over the crest of a vertical face of ice some fifty feet in height.

At the very extremity of the cape we were forced to pass our sledges along a shelf of ice less than three feet in width, glued against the face of the cliff at an elevation which I estimated at the time as seventy-five feet above the ragged surface of the floe beneath.

On the western side of the cape the ice foot broadened and became nearly level, but was smothered in such a depth of light snow that it stalled us and we went into camp. The next day we made Crozier Island.

During April 2 and 3 we were held here by a westerly storm, and the 4th and 5th were devoted to hunting musk oxen, of which three were secured, two of them being very small.

From here I sent back three Eskimos, keeping Henson and four Eskimos with me.

During this time reconnoissances of the polar pack northward were made with the glasses from the summit of the island and from Cape Hecla. The pack was very rough, but apparently not as bad as that which I saw north of Cape Washington two years before. Though unquestionably a hard proposition, it yet looked as though we might make some progress through it, unless the snow was too deep and soft. This was a detail which the glasses could not determine.

On the morning of April 6 I left Crozier Island, and a few hours later, at the point of Cape Hecla, we swung our sledges sharply to the right, and climbed over and down the parapet of the ice foot onto the polar pack. As the sledges plunged down from the ice-foot their noses were buried out of sight, the dogs wallowed belly deep in the snow, and we began our struggle due northward.

We had been in the field now just a month. We had covered not less than 400 miles of the most arduous traveling in temperatures of from —35 deg. to —57 deg. F., and we were just beginning our work—i. e., the conquest of the polar pack, the toughest proposition in the whole wide expanse of the arctic region.

Some two miles from the cape was a belt of very recent young ice, running parallel with the general trend of the coast. Areas of rough ice caught in this compelled us to exaggerated zigzags, and doubling on our track. It was easier to go a mile around on the young ice than to force the sledge across one of these islands. The northern edge of the new ice was a high wall of heavily rubbled old ice, through which, after some reconnoissance, we found a passage to an old floe, where I gave the order to build an igloo. We were now about five miles from the land.

The morning of the 7th brought us fine weather. Crossing the old floe we came upon a zone of old floe fragments, deeply blanketed with snow. Through the irregularities of this we struggled, the dogs floundering almost useless, occasionally one disappearing for a moment, now treading down the snow around a sledge to dig it out of a hole into which it had sunk, now lifting the sledges bodily over a barrier of blocks, veering right and left, doubling in our track, road making with snowshoe and pickax. Late in the day a narrow ditch gave us a lift for a short distance, then one or two little patches of level going, then two or three small old floes, which though deep with snow, seemed like a godsend compared with the wrenching work earlier. Camped in the lee of a large hummock on the northern edge of a small but very heavy old floe. Everyone thoroughly tired, and the dogs utterly lifeless, dropping motionless in the snow as soon as the whip stopped.

We were now due north of Hecla, and I estimated we had made some six miles, perhaps seven, perhaps only five. A day of work like this makes it difficult to estimate distances. This is a fair sample of our day's work.

On the 12th we were storm bound by a gale from the west, which hid even those dogs fastened nearest to the igloo. During our stay here the old floe on which we were camped split in two with a loud report, and the ice cracked and rumbled and roared at frequent intervals.

In the first march beyond this igloo we were deflected westward by a lead of practically open water, the thin film of young ice covering it being unsafe even for a dog. A little farther on a wide canal of open water deflected us constantly to the northwest and then west, until an area of extremely rough ice prevented us from following it farther. Viewed from the top of a high pinnacle this area extended west and northwest on both sides of the canal, as far as could be seen. I could only camp and wait for this canal, which evidently had been widened (though not newly formed) by the storm of the day before, to close up or freeze over. During our first sleep at this camp there was a slight motion of the lead, but not enough to make it practicable. From here I sent back two more Eskimos.

Late in the afternoon of the 14th the lead began to close, and hastily packing the sledges we rushed them across over moving fragments of ice. We now found ourselves in a zone of high parallel ridges of rubble ice covered with deep snow. These ridges were caused by successive opening and closing of the lead. When after some time we found a practicable pass through this barrier, we emerged upon a series of very small but extremely heavy and rugged old floes, the snow on them still deeper and softer than on the southern side of the lead. At the end of a sixteen-hour day I called a halt, though we were only two or three miles north of the big lead.

During the first portion of the next march we passed over fragments of very heavy old floes, slowly moving eastward. Frequently we were obliged to wait for the pieces to crush close enough together to let us pass from one to the other. Farther on I was compelled to bear away due east by an impracticable area, extending west, northwest, north, and northeast as far as could be seen, and just as we had rounded this and were bearing away to the north again, we were brought up by a lead some fifty feet wide. From this on one day was much like another, sometimes doing a little better, sometimes a little worse, but the daily advance, in spite of our best efforts, steadily decreasing. Fog and stormy weather also helped to delay us.

I quote from my journal for April 21:

"The game is off. My dream of sixteen years is ended. It cleared during the night, and we got under way this morning. Deep snow. Two small old floes. Then came another region of old rubble and deep snow. A survey from the top of a pinnacle showed this extending north, east, and west, as far as could be seen. The two old floes over which we had just come are the only ones in sight. It is impracticable, and I gave the order to camp. I have made the best fight I knew. I believe it has been a good one. But I cannot accomplish the impossible."

A few hours after we halted, the ice to the north commenced like the sound of heavy surf, and continued during our stay at this camp. Evidently the floes in that direction were crushing together under the influence of the wind, or, what was perhaps more probable, from the long continuation of the noise, the entire pack was in slow motion to the east. A clear day enabled me to get observations which showed my latitude to be 84 deg. 17 min. 27 sec. north, magnetic variation 99 deg. west. I took some photos of the camp, climbed and floundered through the broken fragments and waist-deep snow for a few hundred yards north of the camp, gave the dogs a double ration, then turned in to sleep, if possible, for a few hours preparatory to returning.

We started on our return trip soon after midnight of the 21st. It was very thick, wind from the west, and snowing heavily. I hurried our departure in order to utilize as much of our tracks as possible before they were obliterated. It was very difficult to keep the trail in the uncertain light and driving snow. We lost it repeatedly, when we would be obliged to quarter the surface like bird dogs. On reaching the last lead of the upward march, instead of the open water which had interrupted our progress then, our tracks now disappeared under a huge pressure ridge, which I estimated to be from 75 to 100 feet high. Our trail was faulted here by the movement of the floes, and we lost considerable time in picking it up on the other side. This was to me a trying march. I had had no sleep the night before, and to the physical strain of handling my sledge was added the mental tax of trying to keep the trail. When we finally camped it was only for a few hours, for I recognized that the entire pack was moving slowly, and that our trail was everywhere being faulted and interrupted by new pressure ridges and leads in a way to make our return march nearly if not quite as slow and laborious as the outward one. The following marches were much the same. In crossing one lead I narrowly escaped losing two sledges and the dogs attached to them. Arrived at the "grand canal," as I called the big lead at which I had sent two Eskimos back, the changes had been such as to make the place almost unrecognizable.

Two marches south of the grand canal the changes in the ice had been such, between the time of our upward trip and the return of my two men from the canal, that they, experienced men that they were in all that pertains to ice craft, had been hopelessly bewildered and wandered apparently for at least a day without finding the trail. After their passage other changes had taken place, and as a result I set a compass course for the land and began making a new road. In the next march we picked up our old trail again.

Early in the morning of the 22d we reached the second igloo out from Cape Hecla and camped in a driving snowstorm. At this igloo we were storm bound during the 27th and 28th, getting away on the 29th in the densest fog, and bent on butting our way in a "bee-line" compass course for the land. Floundering through the deep snow and ice, saved from unpleasant falls only by the forewarning of the dogs, we reached Crozier Island after a long and weary march. The band of young ice along the shore had disappeared, crushed up into confused ridges and mounds of irregular blocks.

The floe at the island camp had split in two, the crack passing through our igloo, the halves of which stared at each other across the chasm. This march finished two of my dogs, and three or four more were apparently on their last legs. We did not know how tired we were until we reached the island. The warm foggy weather and the last march together dropped our physical barometer several degrees.

As we now had light sledges, I risked the short cut across the base of Fielden Peninsula, and camped that night under the lee of View Point. Four more marches carried us to Conger, where we remained three days drying clothing and repairing sledges, and giving the dogs a much-needed rest. Leaving Conger on the 6th of May, eleven marches brought us back to Payer Harbor on the 17th of May. A few days after this I went north to complete the survey of the inner portions of Dobbin Bay, being absent from headquarters some ten days. Open water vetoing a trip which I had planned for June up Buchanan Bay and across to the west coast of Ellesmere Land, the remainder of the time was devoted to assiduous hunting, in order to secure a supply of meat for the winter in the contingency of no ship arriving.

On the 5th of August the new "Windward" sent north by the club, and bringing to me Mrs. Peary and my little girl, steamed into the harbor. As soon as people and supplies could be hurried aboard her, she steamed across the sound to the Greenland side. Here my faithful Eskimos were landed, and after devoting a week or so to the work of securing sufficient walrus to carry them in comfort through the winter, the "Windward" steamed southward, and after an uneventful voyage arrived at Sydney, C. B., on the 17th of September, where I had the pleasure of meeting Secretary Bridgman of the club, and forwarding through him a brief report of my movements during the past year.

THE OTTO ELECTRIC STERILIZER.

While certain large cities have been occupied in applying to their distributing reservoirs of drinking water the process of sterilization by ozone which Nice was the first to adopt in France, it has occurred to some reflecting manufacturers to endeavor to simplify a problem the solution of which is too often retarded by the condition of municipal finances. Why not effect the sterilization, which has to be performed at the origin of the principal water main, at the orifice of every cock in the residences of private individuals? This is a question that has evidently often been asked; but to ask a question is not to answer it. It is necessary at the outset to obtain ozone in sufficient quantity, with a simple and inexpensive apparatus operating with the continuous or alternating currents of low frequency (less than 100 periods per second) furnished by the city mains.

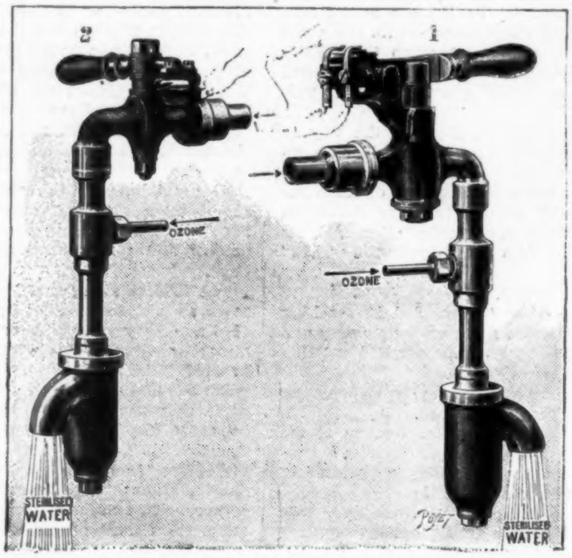


FIG. 2.—ELECTRICALLY STERILIZING WATER COCKS.

1. Lever type. 2. Quarter-way type.

The ozone produced must afterward be intimately mixed with the water to be sterilized. To install Gay-Lussac columns in private houses is something that could not be thought of. The first application of these to the treatment of potable water by ozone dates back to Meritens (1886). The principle of the apparatus is as follows: In a tower filled with inert materials, circulate at the same time an ascending current of gas and a descending one of liquid. The Gay-Lussac columns, employed at Martinikenfeld, Germany, in 1894, were experimented with anew at Paris in 1897, at the works of the Ozone Company at Auteuil, then at Schiedam in 1899, and lastly at Niagara Falls, by M. Otto, in 1903.

M. Otto has greatly increased the Gay-Lussac column by the adjunction of an "emulsifier," a sort of Giffard injector, in which the steam and feed water of the boiler are replaced by the water to be sterilized and the ozone.

The studies pursued by M. Otto establish the fact that a perfect sterilization of the water can be obtained by the use of emulsifiers alone, without the aid of the Gay-Lussac columns. Hence the solution of the problem of the sterilization of water in private houses is found. The emulsifier, in fact, has the advantage of operating both as a suction pump and mixer. If to it there be added an appropriate ozonizer, we shall have all the elements of a genuine works grouped together: a sterilizing gas generator, a suction apparatus, and a mixer of ozone and the water to be treated.

FIG. 1.—OTTO ELECTRO-STERILIZER DIRECTLY CONNECTED WITH ELECTRIC MAIN.

FIG. 3.—OTTO ELECTRO-STERILIZER. HYDRANT TYPE.

A general view of an Otto electro-sterilizer is given in Fig. 1. In a small box provided with a metallic cover and in communication with the ground are grouped a transformer and an ozonizer which are actuated directly by the current of the mains if this is an alternating one. A commutator periodically inverts the current if it is a continuous one. A tin tube leads to the emulsifier the ozone produced, which is drawn directly to the sterilizer by the current of water. The ozone carried along is filtered through cotton wadding, which detains the dust and atmospheric germs. The water and ozone are energetically mixed in the emulsifier. The water escapes through a faucet and carries along the ozone, which it is expedient to employ in considerable excess, as this excess is not only incapable of doing any injury, but is a guarantee of proper sterilization. In a dark room the ozonized water is seen to be phosphorescent. Fig. 2 shows different methods of construction of the emulsifier. The faucet, whether it be a lever (Fig. 2, No. 1) or a quarter-way one (Fig. 2, No. 2) is so arranged as to assure the setting of the ozonizer in operation at the precise moment at which the water is turned on.

The sterilization is perfected in the receptacle into which the ozonized water has been drawn. The "thunder-storm odor" characteristic of electrified oxygen rapidly disappears. The contact of the water and ozone may be prolonged at the exit from the emulsifier by means of various arrangements. Fig. 3 shows one of the simplest and cheapest sterilizing cocks.

The parts for producing the ozone and mixing it with water are identical with those of the preceding apparatus. The phosphorescent emulsion, instead of escaping freely, is directed into a receptacle of enameled iron plate containing a number of concentric tubes. The pure water, of which the apparatus contains an extra supply of several quarts, flows through the lateral spout, while the excess of ozone makes its exit through a small orifice at the upper part of the iron plate receptacle.

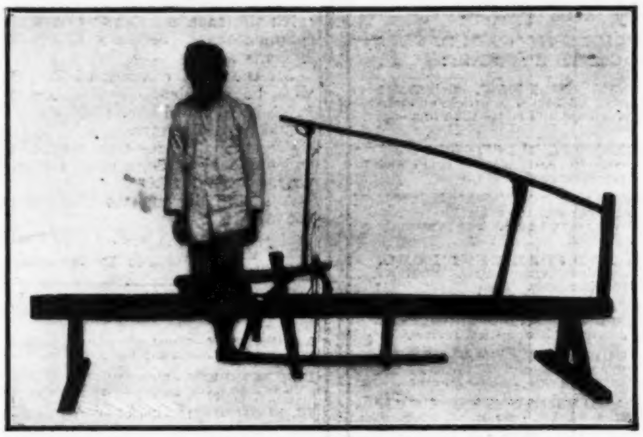
It is estimated by some that ozonized air containing about a grain of pure ozone to the cubic foot is capable of perfectly sterilizing potable water, while others think that it requires at least six grains. In the present state of our knowledge, M. Otto, desiring to put himself beyond criticism, has established his generators in such a way as to furnish from four to five grains of ozone per cubic foot of air. Under such circumstances 0.3 of a cubic foot of air permits of treating ten quarts of water. The ozone generators shown in the accompanying illustration are capable of furnishing a minimum of 7.5 cubic feet of air an hour that permits of practically sterilizing 62.5 gallons of water.

After long researches, it has become possible to reduce the output of electric energy to that furnished by a simple incandescent lamp. The supply of the Otto sterilizer can therefore be easily obtained from the existing electric mains. The expense to private individuals is exceedingly small. Upon ships, in barracks, hospitals, etc., and, in a word, wherever people are congregated and foci of infection exist, the sterilization of water will eventually become a necessity.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE EXTRACTION OF MANILA HEMP FIBER.*

By H. T. EDWARDS.

THE production of Manila hemp, or abacá, fiber is the most important industry of the Philippine Islands. The exports of this fiber for the year 1903 were over two million piculs (123,195 tons), valued at $21,707,575, and representing 66 per cent of the total exports from the archipelago. The fiber has, also, an extensive domestic use for the manufacture of cordage and textile fabrics.



APPARATUS USED FOR STRIPPING MANILA HEMP FIBER.

The invention of a process or a machine for the extraction of Manila hemp is a question of vital importance in the industrial development of the islands. It is difficult to understand why such a machine has never been perfected. The process of fiber extraction is simple. The fiber is well known in all parts of the civilized world. There is a universal demand on the part of the hemp planters for a machine. Notwithstanding these facts, the same slow, laborious, and wasteful hand-stripping process that was employed a century ago is still in use to-day throughout the archipelago.

The plant which produces Manila hemp belongs to the banana family. It closely resembles the common banana plant, the principal difference between the two being that the fruit of the hemp plant is filled with seeds and is non-edible, while the fiber of the banana is so weak as to have but little commercial value. The Manila hemp plant is a tree-like herb 15 to 25 feet high. The fiber is obtained from the stem, or trunk, this trunk being 12 or 15 feet long and from 9 to 18 inches in diameter. It consists of a small central stem, one or two inches in diameter, around which are a large number of thick, overlapping layers, each layer being the stem, or petiole, of a leaf. The fiber is obtained from the outer part of each one of these individual layers.

The process of fiber extraction consists in stripping off ribbon-like layers of fibrous material from each sheath, or leaf stem, and in drawing these ribbons under a knife. The second part of the process separates and cleans the individual fibers. The plant is harvested at the time of flowering, which occurs at from two to three years after planting. The trunk is first cut two or three inches from the ground, and the leaves are lopped off. The native laborer, sitting on the ground, inserts under the fibrous layer of one of the outer sheaths a small piece of bone or metal, called the "locnit," and pulls off a ribbon-like strip two or three inches wide and from six to ten feet long. In this manner each underlying sheath is worked, down to the central stem of the trunk. The ribbons are then collected and taken to some central point, where an apparatus has been set up for drawing the fiber. This apparatus, known as the "panguijan," is simple both in construction and in operation. It consists of a log set in a horizontal position one or two feet from the ground, on the top of which is a block of smooth, hard wood. Over this block is fastened a "bolo," having a blade about one foot long and a handle one and one-half feet in length. A rattan, attached to the end of the knife handle, is connected with a bamboo spring above. A second rattan passes to a foot treadle. The bamboo spring holds the knife down upon the block, the degree of pressure being easily regulated by either lengthening or shortening the rattan. By means of the foot treadle the knife is raised when it is desired to insert or to remove a strip of fiber.

In the process of drawing the fiber, the operator holds in his right hand one or more of the fiber ribbons, together with a short, round piece of wood. The strips, or ribbons, are inserted under the knife, and are drawn through with a quick, steady pull. The strips are then reversed, the cleaned fiber is wound around the stick held by the operator, and the uncleaned ends are drawn under the knife. This process removes all of the pulp and waste material, leaving in the hand of the operator a small bunch of clean, wet fiber. After a few hours of drying in the sun, the fiber is ready for baling and shipment.

This method of fiber extraction is undesirable for several different reasons. The work of fiber stripping is so exhausting that the laborer will seldom work [illegible] than two or three days each week, and even then [illegible]

process is very slow, it being a fair day's work to strip one arroba (25 pounds) of fiber. A large amount of the fiber is wasted. It is estimated that fully 25 per cent of the entire product goes into the waste pile. The quality of the fiber produced is, ordinarily, most unsatisfactory. This is due to the fact that the native laborer, in order to make the work of stripping less difficult, and also to increase the weight of fiber, uses a knife with a serrated blade. With such a blade the individual fibers are only partially separated, and a considerable amount of pulp and extraneous matter is left on the fiber. The resulting product is coarse, of poor color, and lacking in strength.

Numerous attempts have been made, both by the Spanish and by the American residents in the islands, to perfect a machine for the extraction of Manila hemp. Up to the present time, however, no machine has been introduced that will satisfactorily do this work. The greatest difficulty has been that Manila hemp, being a very long fiber, will not stand the strain of full tension while being cleaned. It has been found necessary to wind the fiber around a cylinder, or to hold it in several places with a clutch, in order to lessen this tension. These methods have always resulted in a discoloration of the fiber. The machines which have thus far been introduced have all been based on the principle employed in the old hand process, viz., the extraction of the fiber by drawing the ribbons of fibrous material under a knife.

The successful machine for the extraction of Manila hemp must be one that will not break, tangle, discolor, or in any other way injure the quality of the fiber. As Manila hemp is usually grown in a rough mountainous country, where transportation is difficult and skilled labor not available, the machine should be simple in construction, strong, durable, and portable. The invention and general introduction of such a machine will revolutionize the hemp industry, and will be a most important factor in the future industrial development of the Philippine Islands.

* [illegible]

THE APPLICATION OF SODIUM NITRATE TO THE MANUFACTURE OF MINIUM OR RED LEAD.

MINIUM (red lead), an oxide of lead, which possesses the chemical formula Pb_3O_4, contains, as it occurs in commerce, more or less free lead oxide PbO (Dumas found, for example, from 25 per cent to 50 per cent PbO) and has from time immemorial been employed as a coloring matter. Davy discovered minium in vessels in the baths of Titus at Rome. Both the Greeks and the Romans were well acquainted with this color[illegible] according to Pliny, they were [illegible] since the [illegible] they made it by roasting white lead, a process still applied to the manufacture of orange lead. Nowadays we make red lead or minium for the most part by a dry process, through the conversion of metallic lead in a reverberatory furnace at a moderate heat, first into massicot, yellow lead (PbO), and then by further oxidizing it, through increased heat to from 300 deg. to 400 deg. C., turn it into the red oxide of lead, expressed by Pb_3O_4: $3PbO + O = Pb_3O_4$.

According to Fremy's experiments, minium has the formula Pb_2O_3; and he procures it by a wet process, through the precipitation of the caustic solutions of potassium plumbate and oxide of lead, from which he obtains a yellow precipitate of hydrated oxide of lead, which is converted into red lead by careful heating.

The potassium plumbate, K_2PbO_3 (3HO) is obtained by heating peroxide of lead (PbO_2) in a silver crucible with a concentrated solution of caustic soda. This is decomposed in water and acids, and dissolves in boiling caustic soda lye. Of late we make use of another reaction in the manufacture of minium, one which formerly served for the obtaining of sodium nitrate. Melt potassium nitrate, and add carefully small bits of metallic lead to it, when a very lively and vigorous conversion takes place; the lead becomes oxidized, and the nitrate is transformed into a nitrite: $Pb + KNO_3 = PbO + KNO_2$. The identical reaction takes place when sodium nitrate is employed, except that the sodium nitrite forming is less durable than the potassium nitrite. As a consequence, in this latter conversion process, by-products are always obtained, and the sodium nitrite thus formed is much more difficult to separate from the undecomposed nitrate than the potassium nitrite. For this reason the new process is attended with greater difficulty. For the manufacture of red lead (minium) commercially the process is carried out as follows: Melt the sodium nitrate, and heat it until the iodate, which it almost always contains, is about driven off, and then add by degrees finely divided metallic lead. The theoretical amount of lead is 207 parts to 85 parts of nitrate, but an excess of lead over and above these theoretical figures has been found necessary. Practically, 231 parts of lead are added to 85 parts of the nitrate. The molten mass now contains undecomposed sodium nitrate, peroxide of lead, sodium nitrite, chlorides, sulphates, iodides, metallic lead, and sodium plumbite (Na_2PbO_2), the latter being formed under the development of nitrous gas. The lye is now washed out of the compound with water, and the solution filtered. Oxide of lead and metallic lead remain upon the filter. The oxide is washed out, the metallic lead is sent back to the renewed process, while the lead oxide serves for the making of the minium. The filtrate is subjected to fractional crystallization, and the crystals dried. At first a pure sodium nitrate is obtained, and later the product contains more and more of the impurities.

Now we may add a diluted acid to it, in order to decompose the sodium plumbate, but care must be taken not to overdose it.

To avoid the annoyance arising from the noxious vapors, the distillation for the final crystallization were better done in a vacuum. The commercial product obtained after this manner contains from 95 per cent to 98 per cent of sodium nitrite ($Na.N.O_2$), very often as much as 99 per cent, combined with insignificant quantities of sodium plumbate.

Commercial sodium nitrite is tested by means of a permanganate solution in this wise: Fill a graduated burette with a 2½ per cent solution of the nitrite, and allow it to run into a warm mixture consisting of 350 cubic centimeters of water, 50 cubic centimeters of a 20 per cent solution of sulphuric acid, and 40 cubic centimeters of a 0.8 per cent potassium permanganate solution, until the permanganate solution is completely clarified. Now read from the burette scale the number of cubic centimeters of the nitrite solution consumed, of which each cubic centimeter corresponds to 0.07 gramme of $NaNO_2$, and from this calculate the per[illegible] contained. As a test for the [illegible] of the sample for a quarter [illegible] with 7 cubic centimeters

PROCESS OF EXTRACTING OR STRIPPING MANILA HEMP.

of concentrated nitric acid and 100 cubic centimeters of water. Into this solution allow a 1 per cent solution of sodium nitrite to drip from a burette, stirring continuously the while, until the black precipitate has completely disappeared.

Every 69 grammes of nitrite solution run off corresponds to 239 grammes of PbO_2 (peroxide of lead) and 685 grammes of minium (Pb_3O_4); every cubic centimeter of the consumed nitrite solution contains 0.01 gramme of $NaNO_2$. A similar result may be attained by taking a certain specified weight of the red lead or minium, and decomposing it with diluted nitric acid; the separated lead peroxide may then be filtered out, washed, dried, and weighed. Each gramme of the weighed PbO_2 corresponds to 2,866 grammes of minium (Pb_3O_4). Minium made after the nitrite method is of a more yellowish tinge than that prepared from massicot, but it exhibits a fuller and purer color; its specific weight too is less than that of the massicot red lead.—Revue de Chimie Industrielle.

ENGINEERING NOTES.

The new British armored cruisers of the "Minotaur" class are to have a main battery of four 9.2-inch guns and ten 7.5-inch guns, which is a very powerful offensive force, indeed, for a cruiser. The new guns of 9.2-inch caliber project a shell weighing 380 pounds at a muzzle velocity of 3,100 feet per second, giving a muzzle energy of no less than 25,485 foot-tons, equal to the penetration of 12 inches of Krupp armor at a range of 3,000 yards, while the 7.5-inch pieces impart to a 200-pound shell a muzzle velocity of 3,000 feet per second, and a muzzle energy of 12,540 foot-tons, with a penetrative capacity at 3,000 yards of 8 inches of Krupp armor. These figures are suggestive of the advances in gunnery in the last few years. The Texas has 12-inch guns, the muzzle energy of which, at Santiago, was about 25,300 foot-tons.

A writer in Sparks intimates that low-carbon steel, say about 0.75 to 0.80 carbon, will harden deeper than high-carbon steel containing 1.30 to 1.35 carbon. Low-carbon steel has a much higher heat conductivity and a lower specific heat than high-carbon steel, and these reasons alone may account for the difference, although it is probable that the difference in the chemical action of the constituents of the two steels is also partly responsible. The heat conductivities of 0.750 and 1.330 carbon steel are about as 2 to 1; hence a large piece of steel of low carbon will give up its heat in the bath appreciably quicker than one of high carbon. It also has a slightly lower specific heat so that it contains from 1 to 2 per cent less heat to give up. There is a surprising difference in the thermal conductivity of hard steel, soft steel and wrought iron, the coefficients being 0.062, 0.111 and 0.152 respectively.

Prussian business men and manufacturers are agitating for a relaxation of the building regulations of the most paternal of governments, so that they shall no longer be restricted to structures of moderate height. In Berlin no buildings may exceed 74 feet in vertical elevation, and in this movement for "sky-scrapers" the argument is advanced that modern methods of steel construction insure stability and safety to life, and that, therefore, the 74-foot limit is no longer necessary. The Prussian Ministers of Public Works, Interior and Commerce, who considered the petition, were unmoved by the reference to American experience in the matter of tall buildings, and have for the time being blocked the efforts of those who sought a change. While it is perhaps too late for the exercise of any such spirit of conservatism in American municipalities, where in many cases the mischief is already beyond repair, there is ample room for future reforms. The engineering problems as to the height to which buildings can be carried with due regard to stability of construction, the risk and the safety of the people quartered in them may be left to the architects, insurance experts and firefighters. It is not merely a question of feet and inches, but of civic art, not so much that the limit shall be 74 feet, or 125 feet as in Boston, or 250 feet as in the case of some sky-scrapers; it concerns the proportion which all buildings shall bear to the width of the streets on which they are placed. American cities are already too familiar with instances of structures of faultless design and beautiful proportion dwarfed into insignificance by some towering commercial building, which has nothing to commend it but its impressive height. And the grouping of such structures side by side on narrow streets, entirely regardless of their relation to each other or to the points from which they are viewed, is another evil which has unhappily come to be regarded as a matter of necessity. There is little prospect or hope that American cities for many years to come will consent to the restrictions in architectural design and size which have made Paris so noteworthy, but Philadelphia has a peculiar opportunity in its various boulevard projects to take a step in the right direction. The millions to be expended for the condemnation of land, the opening of broad avenues and the planting of trees will be worse than wasted if no control is exercised over the style and class of buildings which are to be erected. It will be no easy task to control by statute or municipal ordinance, especially where legislation owes its origin to interested grafters, but certain broad principles and proportions can be laid down to the great benefit of the city, the boulevards, and the property owners. Such a plan, with the advice of skilled artists and architects, would lend dignity and beauty to what may very easily become something wholly different.—Philadelphia Public Ledger.

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